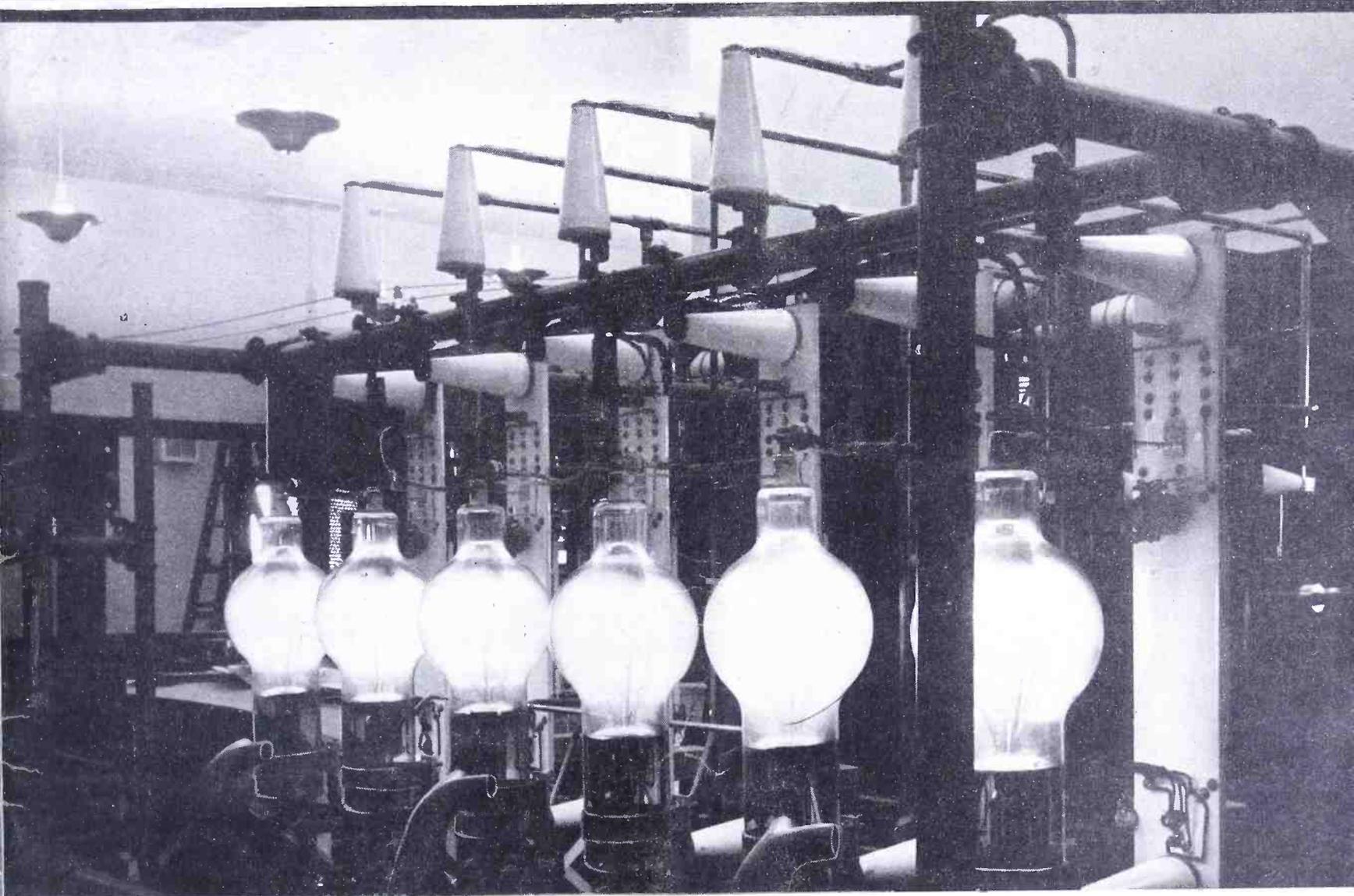


# COMMUNICATIONS



*AUGUST*

- ★ RADIO ENGINEERING
- ★ PRE-FLIGHT COMPASS TESTS
- ★ A-N MICA CAPACITOR STANDARDS

- ★ NAB WAR CONFERENCE
- ★ BROADCAST ANTENNAS AND ARRAYS
- ★ RESISTIVE NETWORKS

1944

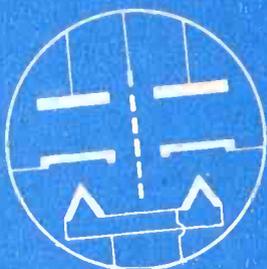
# NO SUBSTITUTE NEEDED!

USE  
**HYTRON 6AL5**

**VERY-HIGH-FREQUENCY TWIN DIODE**

## TYPE 6AL5

(Developmental  
Hytron D27)



### BASING

- Pin 1 — Cathode 1
- Pin 2 — Plate 2
- Pin 3 — Heater
- Pin 4 — Heater
- Pin 5 — Cathode 2
- Pin 6 — Shield
- Pin 7 — Plate 1

### CONSTRUCTIONAL FEATURES

- 1 Rugged mount is supported by short, heavy stem leads as well as by top mica.
- 2 Close cathode-to-plate spacing gives high perveance. (Note plate cooling fins.)
- 3 Electrostatic shield connects to pin 6.
- 4 Baffle mica shields the elements from getter spray.
- 5 Miniature stem permits negligible lead inductance and minimum interelectrode capacitances.



The 6AL5 fills the need for a high perveance twin diode with the low voltage drop required for many special r.f. circuit applications. WPB and the Services consider diode connection of the 6J6 twin triode (and other triodes) to be a wasteful misuse. With minor changes of socket wiring, the 6AL5 easily replaces the diode-connected 6J6.

Specifically manufactured and rated as a diode, the 6AL5 is tested as a diode. Close production control keeps within a narrow range the cutoff characteristic in the contact potential region. Designed throughout for efficiency on high and very-high radio frequencies, the 6AL5 has a separately connected shield which may be grounded to isolate the two diodes and their associated circuits. A midget miniature bulb permits extra space savings.

Possible uses include: Detector and AVC, clipper, limiter, FM frequency discriminator, special high-frequency diode, power rectifier.

## HYTRON TYPE 6AL5

Very-High-Frequency Twin Diode

### ELECTRICAL CHARACTERISTICS

|                                  |                |
|----------------------------------|----------------|
| Heater potential (AC or DC)      | 6.3 volts      |
| Heater current                   | 0.3 amperes    |
| Peak inverse potential†          | 460 max. volts |
| Heater-cathode potential†        | 350 max. volts |
| Peak plate current per plate†    | 60 max. ma.    |
| Average plate current per plate† | 10 max. DC ma. |

### INTERELECTRODE CAPACITANCES

|                    |            |
|--------------------|------------|
| Plate 1 to plate 2 | 0.015 mmf. |
| Plate to cathode*  | 2.8 mmf.   |
| Cathode to all*    | 3.8 mmf.   |

Capacitances are averages with close-fitting shield.

### PHYSICAL CHARACTERISTICS

|                |                        |
|----------------|------------------------|
| Bulb           | T-5½ midget            |
| Base           | Miniature button 7-pin |
| Height overall | 1.82 inches max.       |
| Diameter       | 0.75 inch max.         |

† Maximum ratings shown are absolute; design maximums should be approximately 10% lower to allow for line voltage variations.  
\* Value is for one of the two twin diode sections.

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

# HYTRON

**CORPORATION** ELECTRONIC AND RADIO TUBES

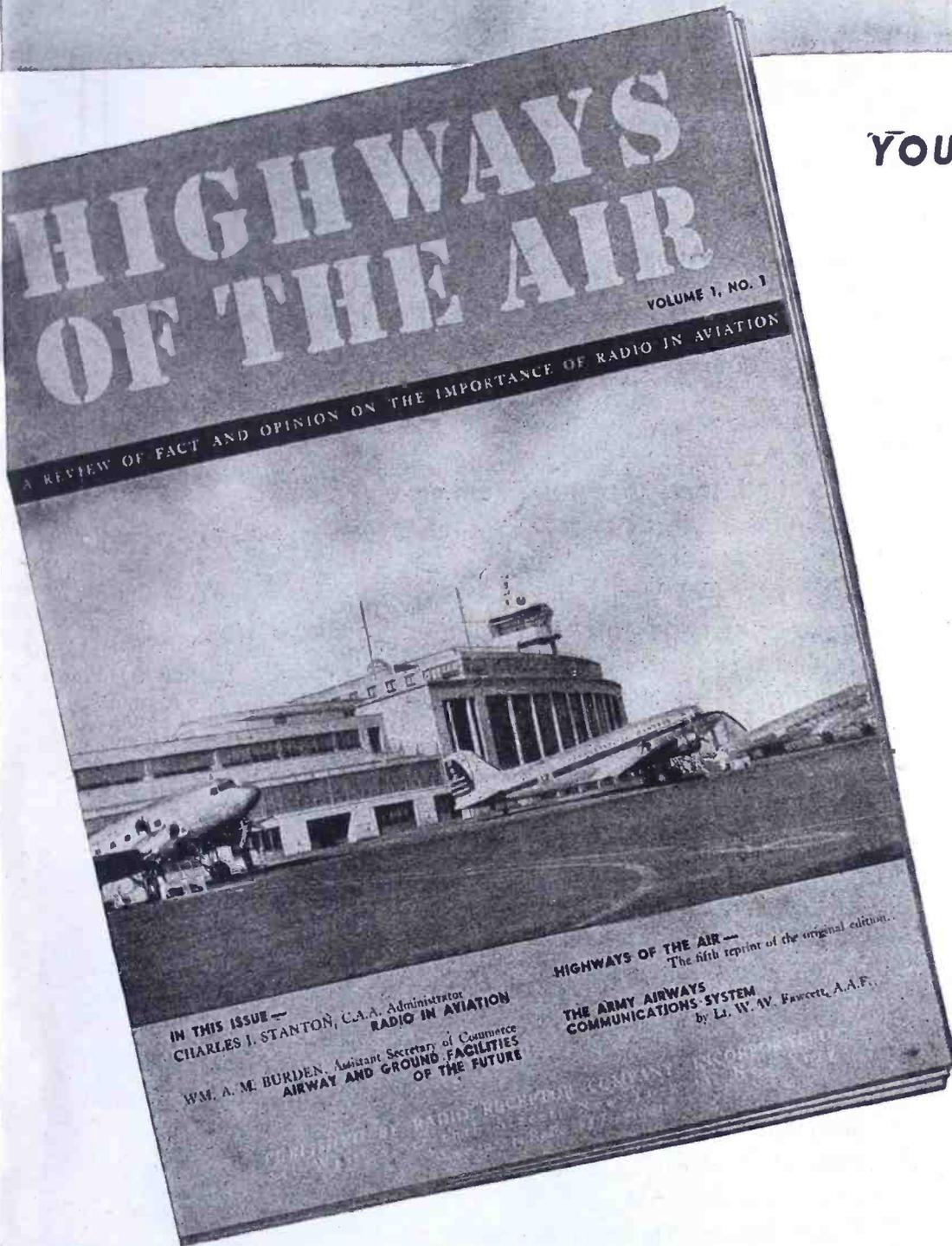
SALEM AND NEWBURYPORT, MASS.



**BUY ANOTHER WAR BOND**

# “HIGHWAYS OF THE AIR”

*Important to everyone interested in airports and aviation*



This issue is No. 1, Volume 1—others will follow if you request them. Contents are authoritative—but non-technical—designed to inform the layman on a subject which is becoming of increasing importance.

Send for your copy on your letterhead—we are glad to send it as our contribution to a greater Air-America.

## YOU SHOULD KNOW—

What is the "bottle-neck" in post-war expansion of civil aviation . . . . . See page 8

Why CAA is installing Ultra High Frequency radio ranges. See page 8

What anti-collision devices are being developed . . See page 9

What electronic aircraft detectors are . . . . See page 9

What can civil aviation learn from the A.A.C.S. . . See page 2

What goes into an instrument landing system . . See page 11

What is approach control. See page 11



These questions and dozens of others of vital import to all those interested in the development of radio in aviation for increased safety of human life and property are discussed in the pages of "HIGHWAYS OF THE AIR"



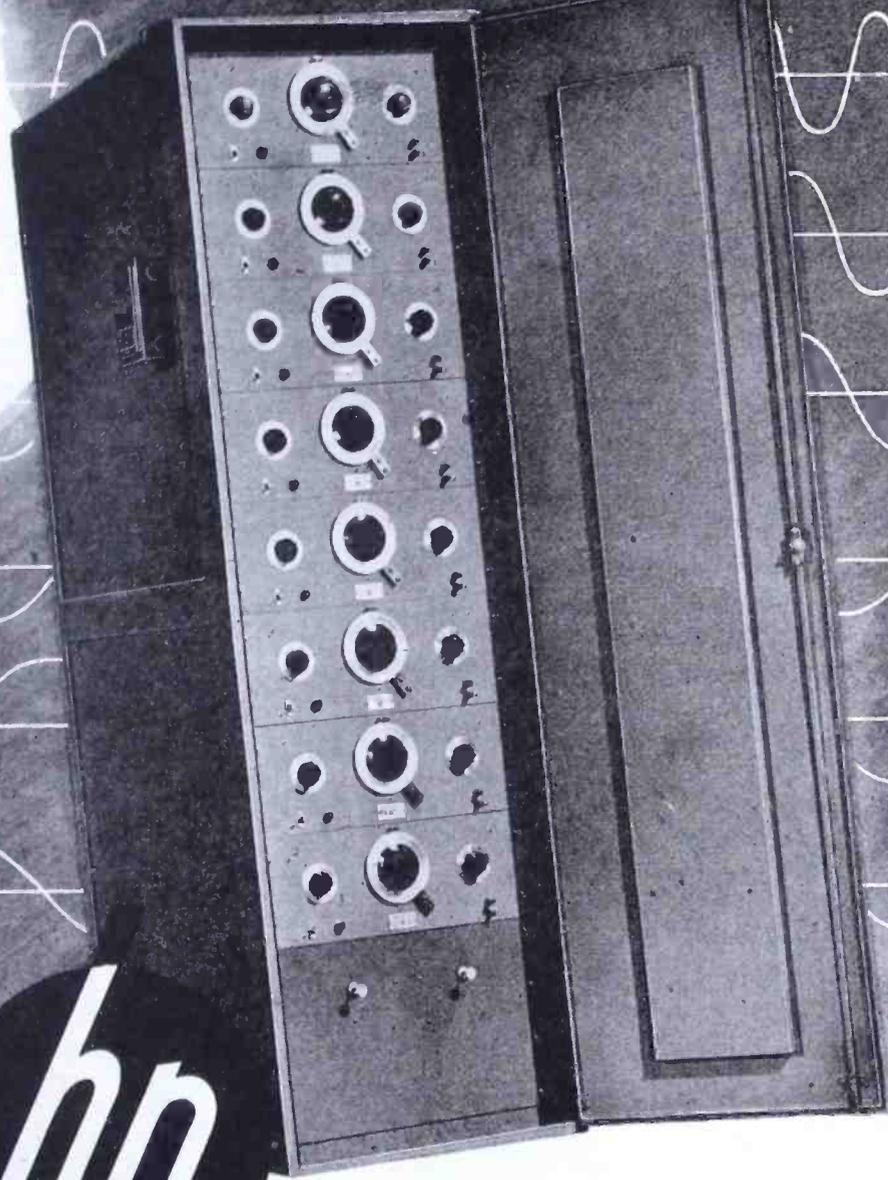
## RADIO RECEPTOR CO., INC.

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Engineers and Manufacturers of Airway and Airport Radio Equipment • Communications Equipment • Industrial Electronics • Electronic Heating Equipment  
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**MAINTAINS  
8 FIXED FREQUENCIES  
WITH ACCURACY OF  
1 PART IN 2000  
OVER LONG PERIODS**



**hp**  
-hp- Instruments are rated within conservative limits because of the wide range of applications which are normally encountered. However, their performance can be depended upon within much closer limits when proper care is taken.

For example: -hp- Audio-Oscillators are rated to maintain accuracy within 2 parts in 100 yet here is a case where they are performing successfully in an application which requires accuracy to be within 1 part in 1000. In this case the problem was to supply 8 separate frequencies simultaneously for continuous laboratory and production testing.

8 Standard -hp- model 200BR, Resistance-Tuned Audio Oscillators were mounted in a single rack and each set to a desired frequency. The Oscillators were then enclosed in a

temperature controlled chamber which maintains operating conditions close to the ideal. The result: accuracy is maintained to 1 part in 2000... which is 40 times better than the normal ratings for the oscillators, and even better than the strict requirements of the applications.

-hp- Resistance-Tuned Oscillators require *No Zero Setting* and they have but 3 control dials on the panel. Their simplicity of operation makes for great speed in production testing with no sacrifice of accuracy.

-hp- Engineers are ready and willing to assist you in any special problem. Just drop a note giving the details. There is no cost or obligation. Ask for catalog number 17A.

Such performance serves to assure you of the dependability of -hp- specifications. -hp- Instruments will always perform up to published ratings.



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077

COMMUNICATIONS FOR AUGUST 1944 • 3

# JAMES KNIGHTS

# Crystals



## A Habit With Us-- HERMETICALLY SEALED **ETCHED Crystals**

The engineers of the James Knights Company pioneered in the development and manufacture of Etched quartz crystals. For some time now, we have been supplying quantities of these definitely better type crystals in hermetically sealed holders. James Knights Etched Crystals are available to improve the performance of your equipment. Catalog on request.

BUY WAR BONDS FOR VICTORY!

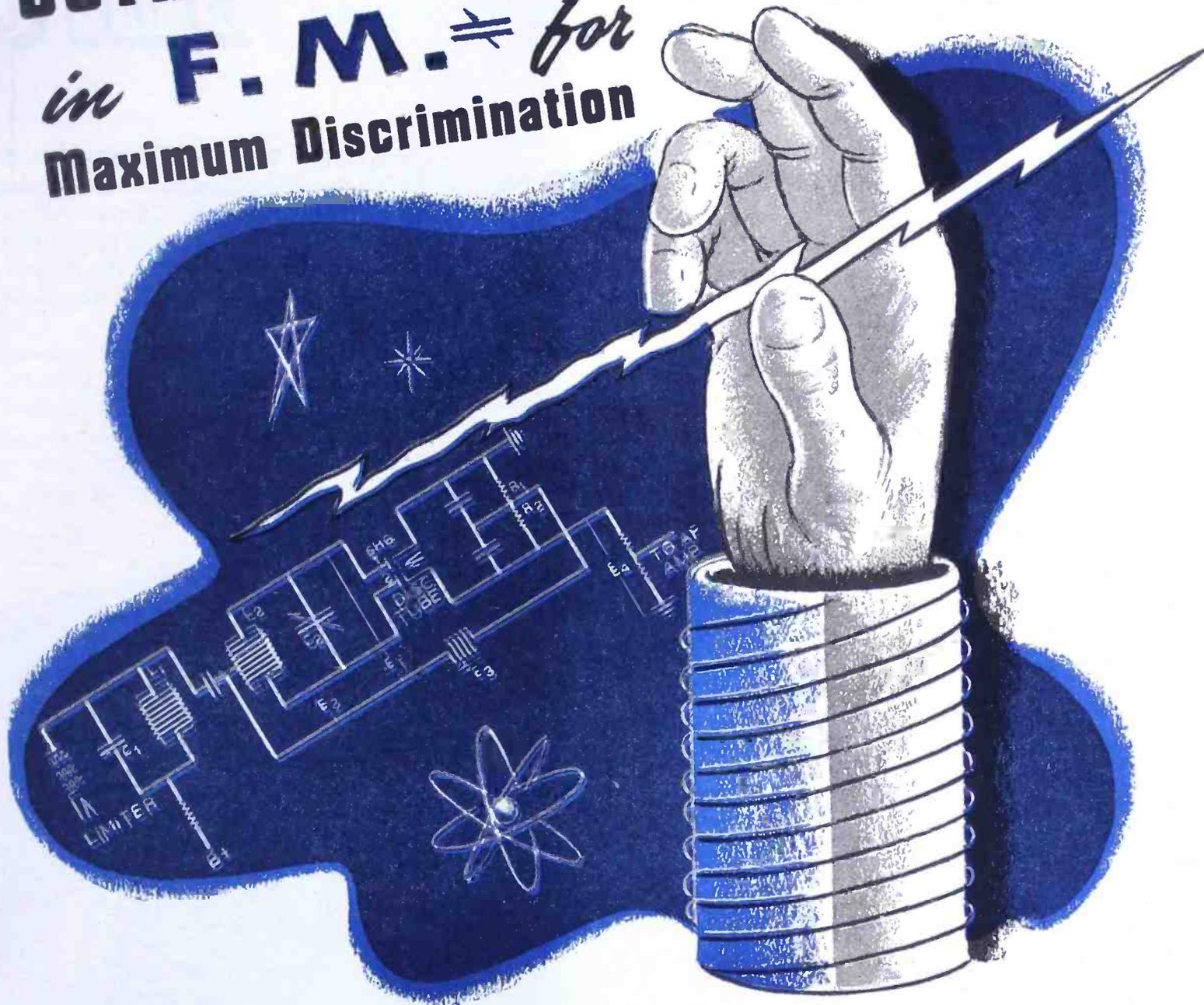
**The JAMES KNIGHTS Co.**  
SANDWICH, ILLINOIS



## CRYSTALS FOR THE CRITICAL

# GUTHMAN Discriminator COILS

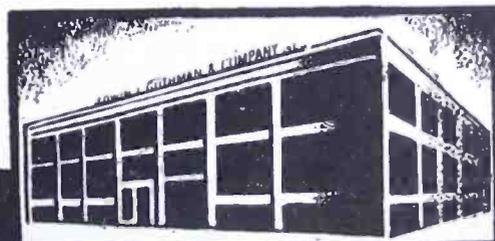
in F.M.  $\Rightarrow$  for  
Maximum Discrimination



FREQUENCY MODULATION receivers require linear discrimination against undesirable signals. Guthman engineers have developed precise DISCRIMINATOR COILS to discriminate equally on both sides of the resonance curve, providing maximum discrimination.

**G**UTHMAN  
*Leader in  
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INVEST IN WAR BONDS!



**EDWIN I. GUTHMAN & CO.** INC.

15 SOUTH THROOP STREET · CHICAGO

PRECISION MANUFACTURERS AND ENGINEERS OF RADIO AND ELECTRICAL EQUIPMENT

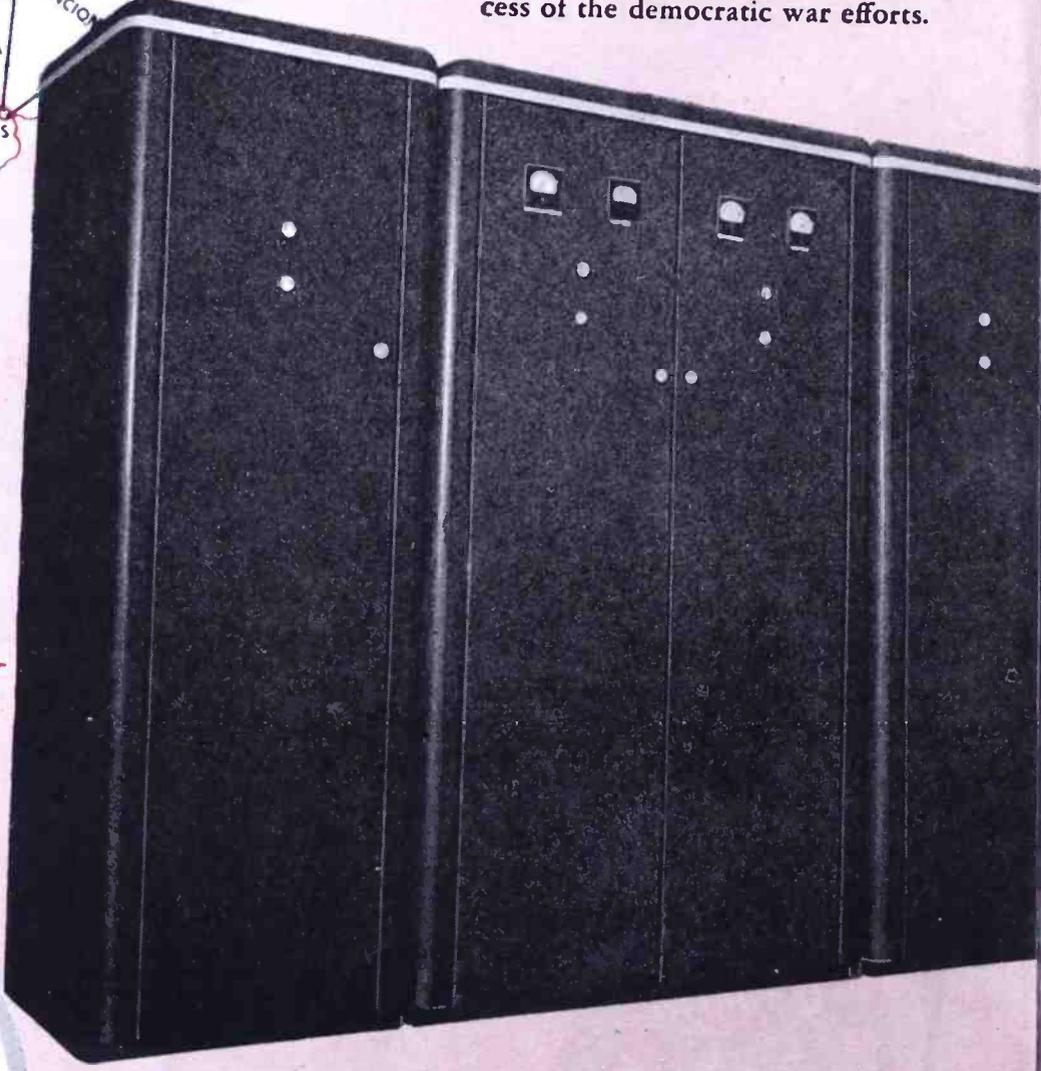


★ **ALONG THE PANAGRA ROUTE** is located AAC transmitting equipment at approximately 30 different points in Colombia, Ecuador, Peru, Chile, Bolivia and Argentina—forming the nucleus of the radio navigation and communications system.

Panagra is today primarily devoting its personnel and facilities to maintenance of aerial lifelines between the Americas, across which are speeding men, mail and materials vital to the success of the democratic war efforts.

TODAY, the skill and experience of the AAC Electronics and Hydraulic Divisions are devoted to serving a fighting America. However, AAC engineers are planning ahead for the great peacetime future when new and improved AAC products will be ready to meet postwar needs.

(Right) Type 500 Transmitter as designed by AAC for Panagra. Consists of multi-channel transmitting equipment, 1,000 watts each channel. Two channels may be operated simultaneously. Telephone and telegraph transmission. Frequency range 250-550 KC and 1500-12000 KC.



*Randolph C. Walker* PRESIDENT

**AIRCRAFT**  
Manufacturers of **PRECISION**  
Burbank, Calif. Kansas

# TRANSMITTERS AND OTHER COMMUNICATIONS EQUIPMENT

*for*

## Dependable Operation Of Airlines And Various Communication Services

★ Today, AAC transmitters and other AAC communications equipment play a vital part in dependable operation of warplanes on the fighting fronts, as well as airlines serving the war-busy Americans on the home fronts.

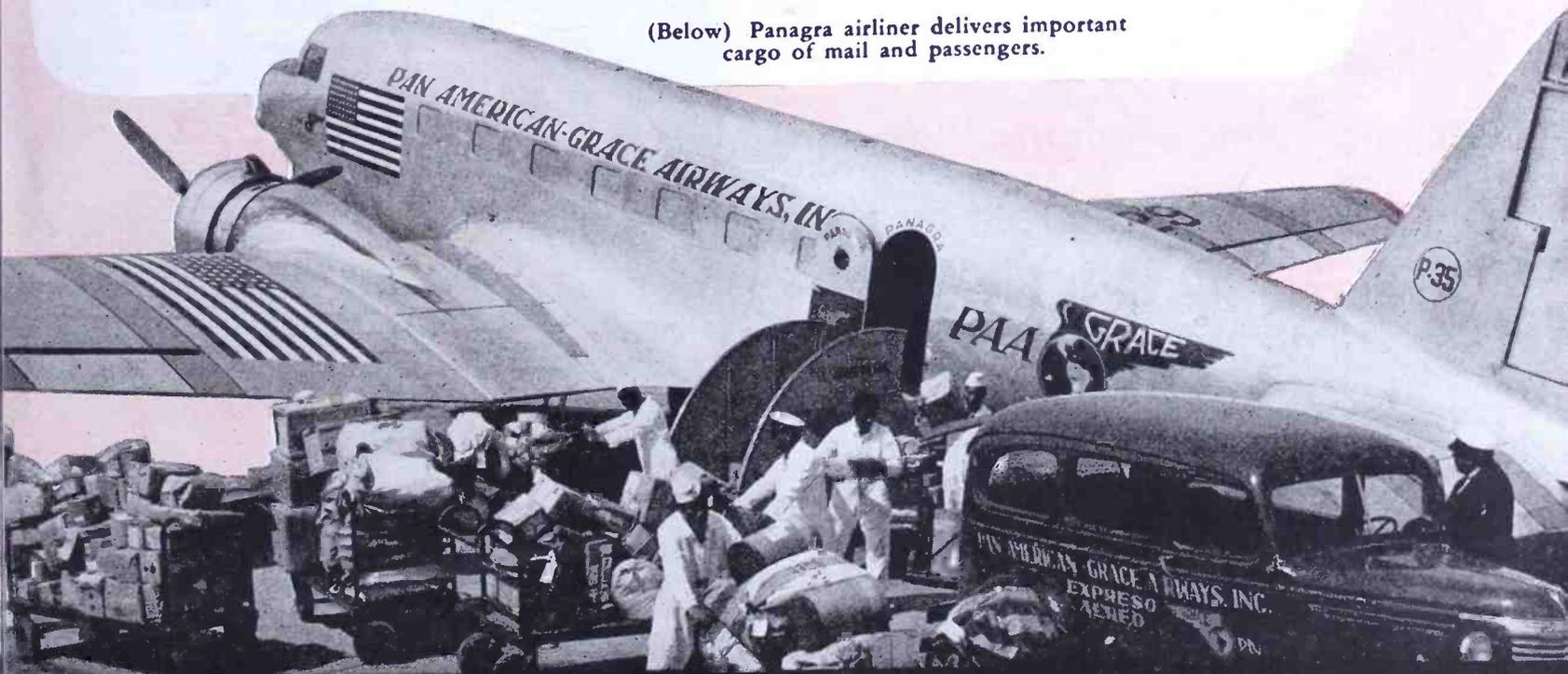
AAC Electronics Division has won distinctive leadership as one of the country's large producers of radio transmitting and receiving equipment. One outstanding example of AAC communications engineering is the equipment designed and built to meet the specified needs of Pan American-Grace Airways, Inc. Consisting of a multi-channel 1,000 watt transmitter, this equipment is used by Panagra for radio homing and communication purposes. It represents one of a complete line of transmitting equipment for use by airlines or services having similar communication needs.

At the present time practically all AAC facilities are devoted to war production. However, your inquiries are welcomed now for commercial equipment which can be supplied in limited quantities if adequate priority ratings are available.

AAC products in transport planes, cargo carriers, troop ships, bombers . . . airport traffic net, police or other services where communications are crucial, can be depended upon as expertly engineered and built to the most efficient performance standards.

Products of **ELECTRONICS DIVISION**  
TRANSMITTERS • AIRCRAFT & TANK ANTENNAS • QUARTZ CRYSTALS • RADIO TEST EQUIPMENT

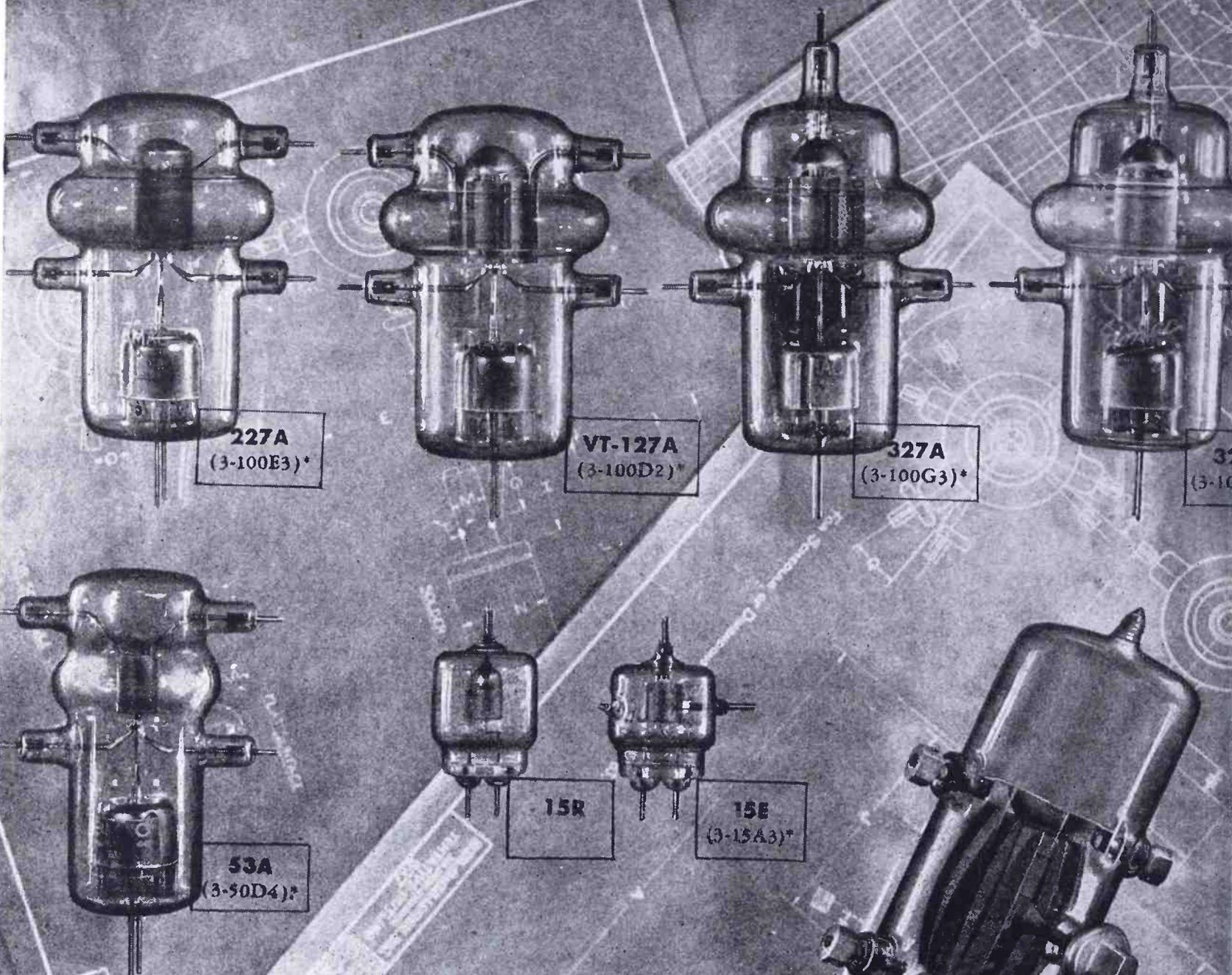
(Below) Panagra airliner delivers important cargo of mail and passengers.



# A ACCESSORIES CORPORATION

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City, Kans. New York, N. Y. Cable Address: AACPRO



**227A**  
(3-100E3)\*

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**327A**  
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**327A**  
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**53A**  
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**15R**

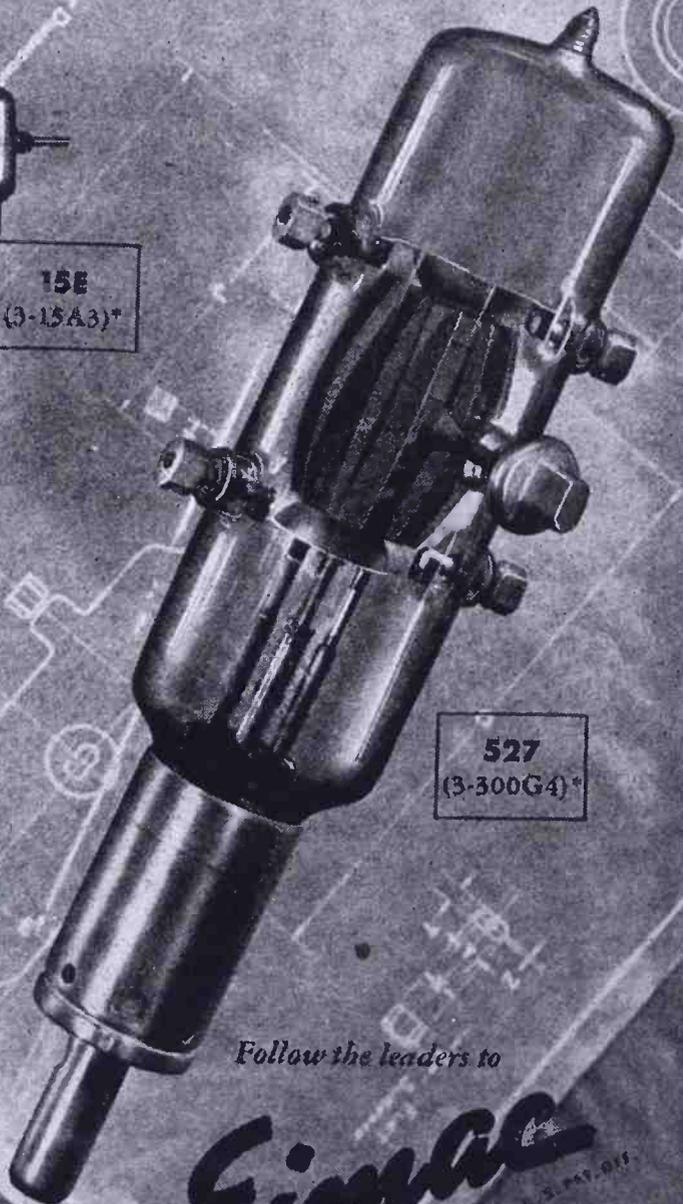
**15E**  
(3-15A3)\*

**527**  
(3-300G4)\*

**Here are 8 special purpose Vacuum Tubes originated, developed and quantity produced by Eimac during the past few years**

\*The designations on these tubes are new Eimac type numbers which are descriptive of the tube characteristics. For example (3-100G3) the first digit 3 indicates triode, the figure 100 indicates plate dissipation, the letter "G" indicates physical type and the last digit 3 is a code indication of the mu of the tube.

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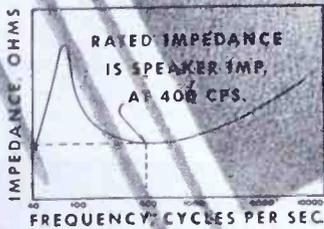
**Eimac**  
REG. U.S. PAT. OFF.  
**TUBES**

**EITEL-McCULLOUGH, INC., 882 San Mateo Avenue, San Bruno, California**

Plants located at: San Bruno, California

and Salt Lake City, Utah

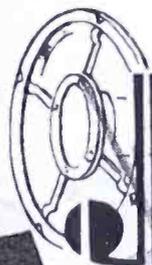
# How to Match Impedance and Distribute Power in Loud Speaker Systems



Here is Number 2 in the series of practical, instructive Monographs prepared by the Jensen Technical Service Department. The title, "Impedance Matching and Power Distribution in Loud Speaker Systems," suggests the scope and treatment of a subject in which everyone concerned with loud speakers and the reproduction of sound, is vitally interested. ¶ The reading material is supported by twenty-eight drawings and tables. More than a score of questions are described, illustrated and solved. One of the problems is that of a comprehensive sound system for a military installation. ¶ Like Monograph Number 1—"Loud Speaker Frequency-Response Measurements"—Number 2 is offered by JENSEN in the interest of improved sound reproduction. Get either copy, or BOTH, from your jobber or dealer, or fill out the coupon and mail it with 25c for each book, to:

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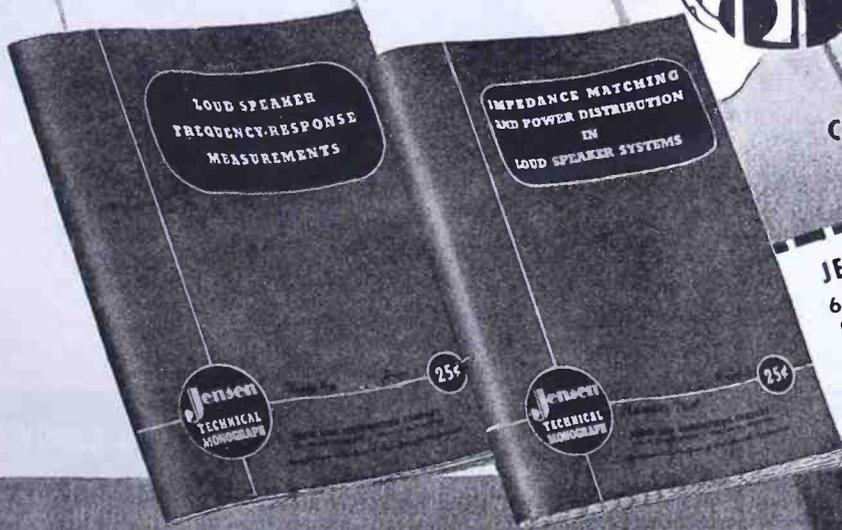
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# THE WAR WILL END ON



-----  
**(YOU FILL IN THE DATE)**

Think of it! You as a civilian have the power to decide when the war will end. Use that power to the utmost—NOW—by

1. Buying war bonds to the limit of your capacity.
2. Working harder, longer, and uninterruptedly turning our implements of war.
3. Donating your blood to the Red Cross to save lives on the battle field.
4. Collecting waste paper and other scrap for which the government is asking.
5. Avoiding black markets as you would the plague. (Black markets cause the plague of inflation.)

All of these are weapons of war—weapons that strike terror in the hearts of our enemies. Use them.

We, the management and employees alike, at Kenyon, are building better transformers than we ever built before—and building them faster for the armed forces.



THE MARK OF

EXCELLENCE

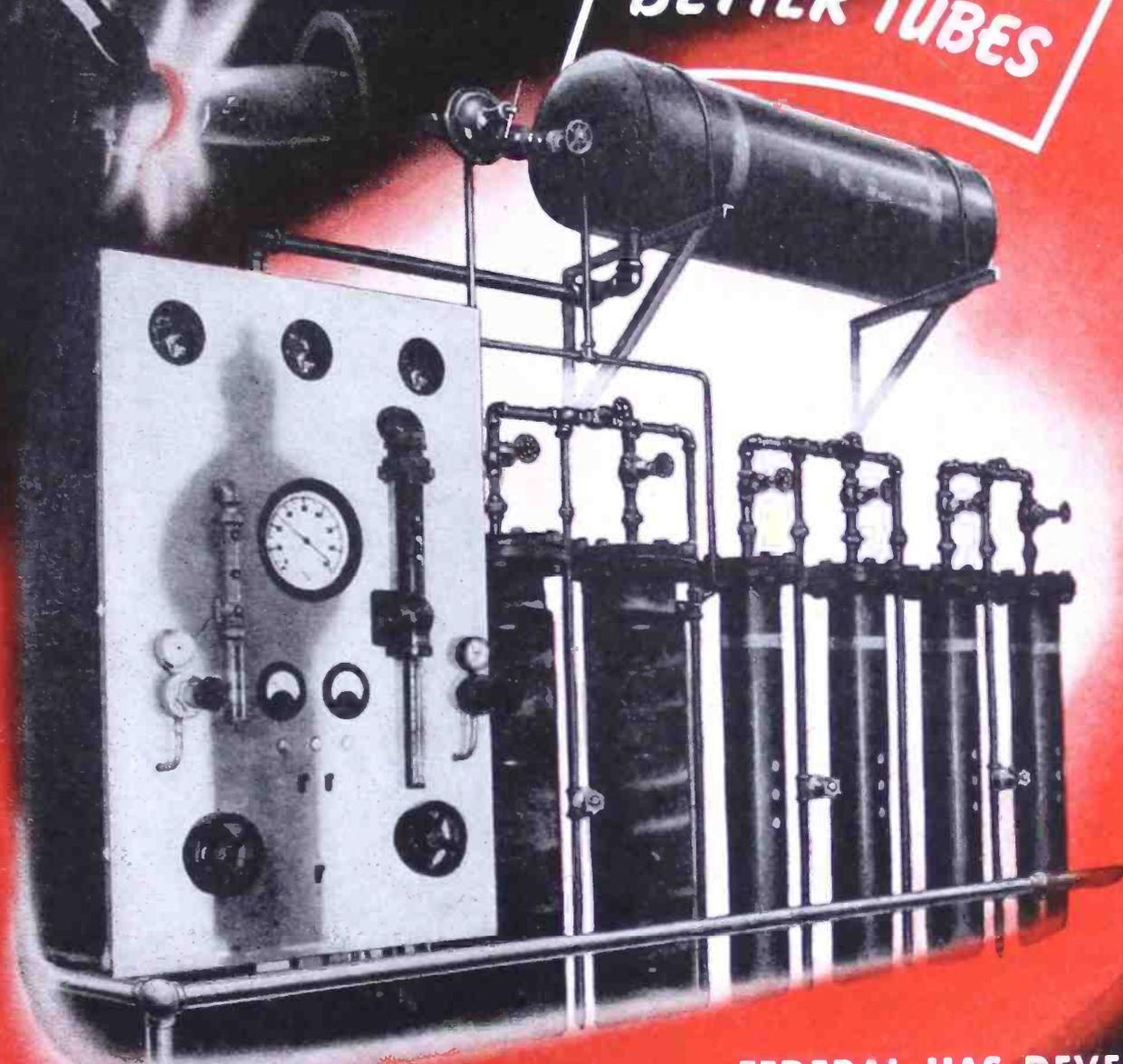


## KENYON TRANSFORMER CO., Inc.

840 BARRY STREET  
NEW YORK, U. S. A.

**NO OXIDATION  
NO CONTAMINATION  
NO MOISTURE . . .**

**3 MORE REASONS WHY  
FEDERAL MAKES  
BETTER TUBES**



**FEDERAL HAS DEVELOPED  
THE FIRST NITROGEN PURIFIER**

No oxidation, no contamination, no moisture!

Another Federal First adds extra performance guarantees to FTR vacuum tubes.

In a corner of the new FTR tube plant is this automatic nitrogen purifier. During the process of sealing the anode to the stem, the elements of every FTR tube are now protected from oxidation, contamination and moisture in a

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**NOW! A WORKING MODEL OF GATES  
POST-WAR TRANSMITTER DESIGNING**

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for Post-War Delivery\***

*Gates*

**MODEL 1D  
ONE KILOWATT**

## **BROADCAST TRANSMITTER**

*An Example of How Gates Wartime Developments Create Higher Efficiency at Lower Cost*

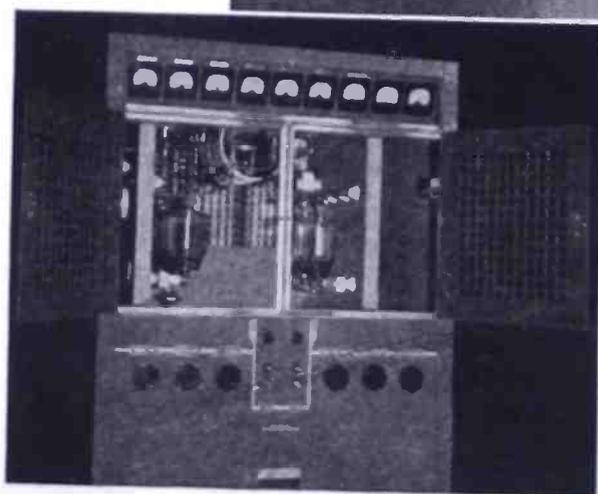
Here is "tomorrow's transmitter — completely engineered today!" Combining these important features:

- Low initial tube cost
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- High fidelity performance
- Extreme accessibility of all components
- Modern, streamlined design
- Extremely easy to install
- "Easy-view" meter panel

Yes! Gates is ready for your post-war equipment needs. This new, 1000 watt transmitter is completely designed and operating under rigorous conditions . . . ready for post-war delivery. The Model 1D is designed as a commercial broadcast transmitter, but is also available, on special order, for high frequency operation up to 20 megacycles. You can order now with confidence, knowing that Gates has taken advantage of every wartime engineering advancement in designing this efficient and economical transmitter.

*\*May we send you details regarding the Gates Priority System for prompt postwar delivery?*

**WRITE TODAY FOR COMPLETE,  
ILLUSTRATED TECHNICAL BULLETIN**



*Model 1D — 1000  
watt Transmitter.  
Full front view  
and close-up of  
front top with  
doors open.*

Wartime restrictions do not allow the sale of new broadcasting equipment without priority. This equipment is presented merely to acquaint you with Gates developments.

*Gates*

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**not just a task force**



**but Full Capacity Production at G. I.**

All in all, industry did, and is still doing, a grand job — has rolled up a stupendous record of accomplishment in the past four years. But, looking back, we can see errors of procedure which made the going tough in spots, obstacles that retarded progress. These conditions were due to confusion and lack of experience in the drastic conversion from civilian to war production. Our industry can

well profit by these mistakes as we make the transition back to peacetime activity.

We at G. I., anticipating WPB's recent Go-Ahead signal, have readied definite plans — plans which will enable us to swing into capacity execution of post-war assignments the instant our facilities are no longer wholly required for the supplying of military equipment.

**GENERAL INSTRUMENT CORP.**

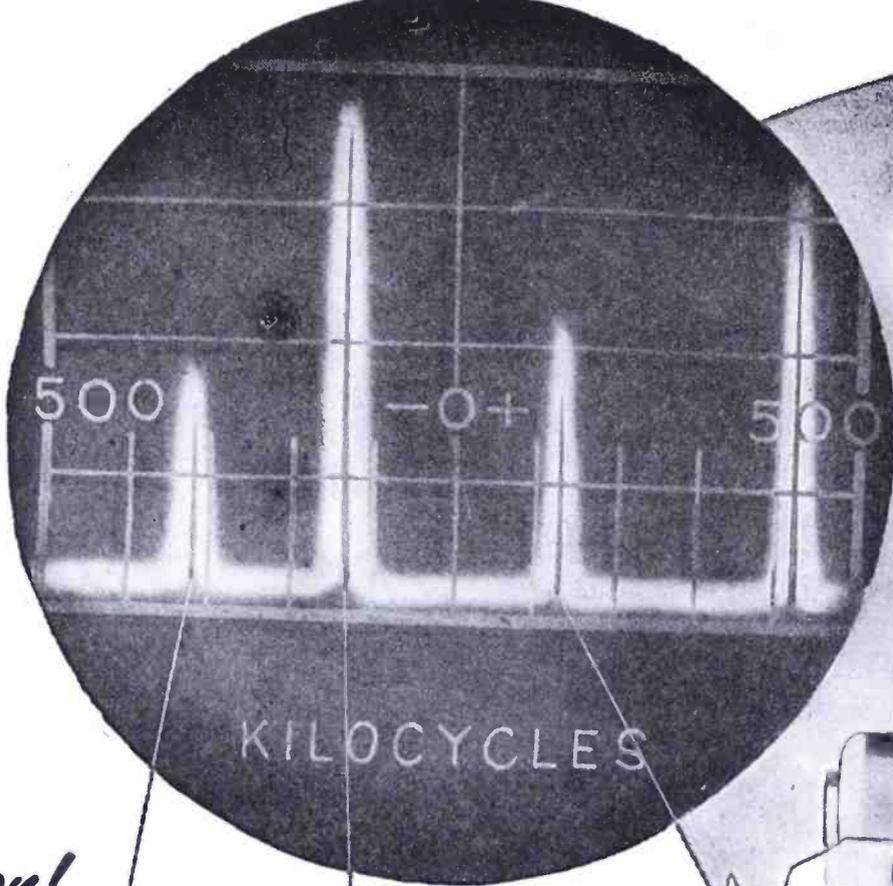
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**OUR WARTIME JOB** has been the volume output of variable condensers, many with circuit applications never before possible, wired assemblies, automatic tuning mechanisms, etc.



**OUR PEACETIME JOB** will be to produce such precision instruments, featuring new designs, innovations and improvements, for civilian use in the fields of electronics and communications equipments.



Soon!

# PANORAMIC RECEPTION

WILL BE USED BY GI JOE WITH HIS "HAM" RIG

When GI Joe takes off his helmet, he will still remember many of the things he is learning in the Army. As a radio operator, he uses **Panoramic** reception for effective monitoring and for catching tricks in enemy field communications. He recognizes its value for peacetime as well as for wartime. On the basis of military experience, he will want to make use of **Panoramic** reception for many more pleasant hours at his own rig. Because it **SHOWS ALL SIGNALS ON A GIVEN BAND OF THE RADIO FREQUENCY SPECTRUM SIMULTANEOUSLY**, GI Joe knows that **Panoramic** reception will tell him what stations are on the air, whether they are phone or CW, and what their signal strengths are when

they reach him. Most important he can be sure that he will miss very few calls in response to his CQ's.

Currently, **Panoramic** reception also is doing good work in laboratory development and industrial applications. Its ability to measure, interpret and compare variations in inductance, capacitance and resistance has created possibilities that are being utilized by far-sighted manufacturers. If **Panoramic** technique can be adapted to your present or future needs, ask our engineers for more detailed information.



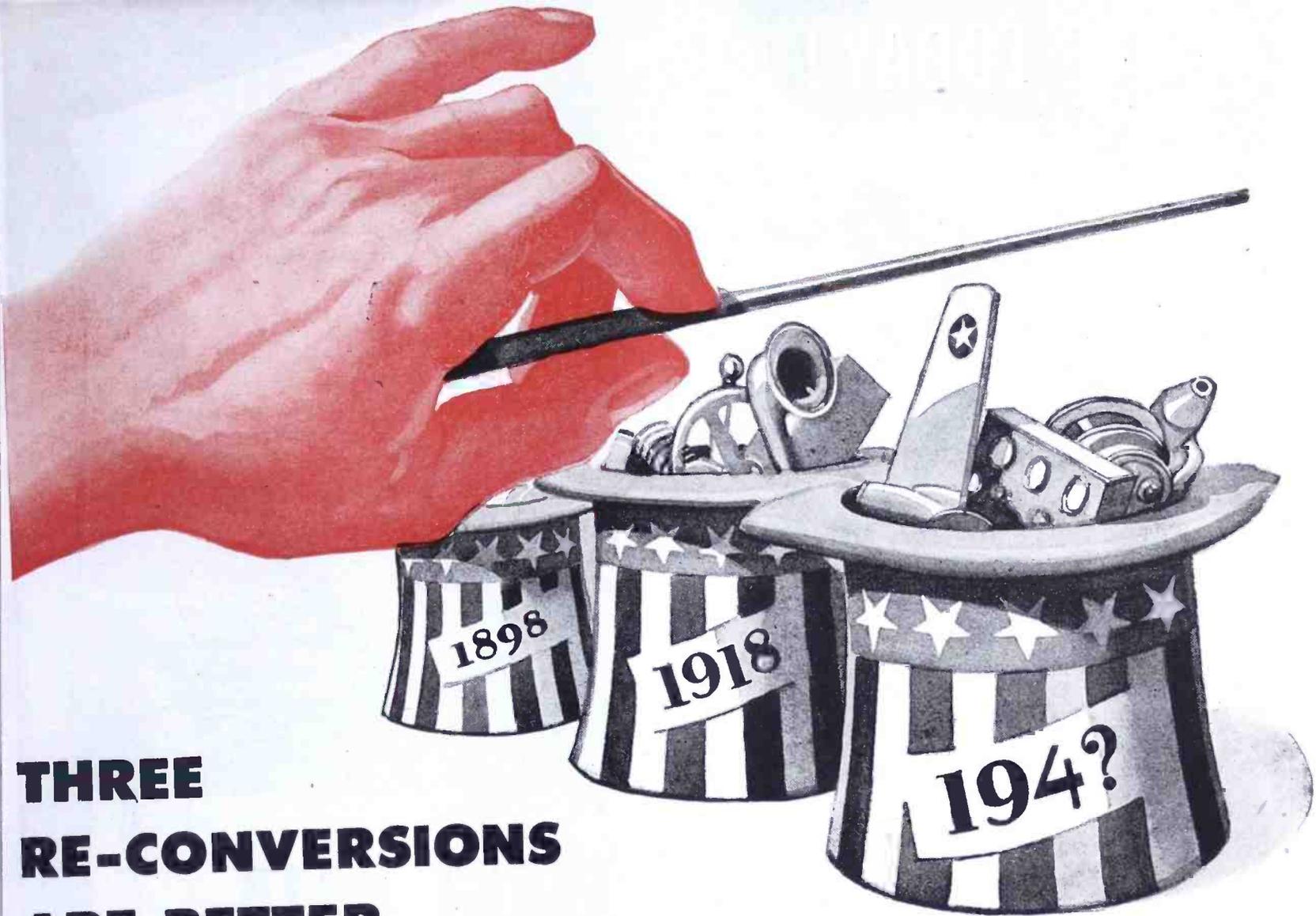
COMMENT  
CAVA?



PANORAMIC

RADIO CORPORATION

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# THREE RE-CONVERSIONS ARE BETTER THAN ONE

## HOW TO AVOID WAR CONTRACT "STYMIES" ON POST-WAR PRODUCTION

Lewyt offers a solution of this problem to a manufacturer who "fits" into our schedule. Perhaps we can *plan now* to assist with your electronic, electrical and mechanical parts production, or complete assembly, chassis and housings. Write for 48-page illustrated book, "Let Lewyt Do It". No cost or obligation. Consult Thomas Register for Lewyt listings.

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American Industry drafted us by their own *selective service act* to fight their parts-production battles 53 years before Pearl Harbor. We've been in thousands of engagements . . . we've employed every known strategy . . . and some secret devices of our own . . . to defeat high production costs.

War-born companies of the 1940's have had no experience with peacetime invasions on competitive-cost strongholds. When "C-Day," comes the Conversion Casualty List will be high among sub-contractors brought up in the "Cost-Plus School" of production.

Lewyt is *not* a war baby. Lewyt is a "Manufacturer's Manufacturer" with 56 years' experience devising less costly methods of making things better. Lewyt has the *peacetime* production ability you need. Maybe we can't figure on your re-conversion manufacturing problems *now*. But we can quote on WAR BONDS. They start at \$18.75.

# Lewyt

LET LEWYT DO IT

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GET ACQUAINTED  
NOW WITH THE  
RESISTORS OF  
TOMORROW!



## HERE'S THE LATEST DATA... on the most up-to-the-minute resistors

Time and again, during the past seven years, Sprague Koolohms have demonstrated convincingly their ability to handle jobs that old-style, conventional wire-wound resistor types could not handle satisfactorily.

One after another, they have proved their superiority in practically every essential characteristic — from faster

heat dissipation with resulting use up to full rated wattage values, to better performance under humid conditions.

Whether for war use today, or for greater efficiency for your post war product tomorrow, it should pay you to become fully acquainted with this remarkable resistor development. Write for this big new catalog today!

### Resistor types in this new catalog include:

Wire-wound power types, 5- to 120-watts. Inductive and non-inductive.

Hermetically-sealed wire-wound types, 10- to 120-watts.

Wire-wound bobbin types.

Voltage divider sections, 10-, 15- and 25-watts.

Hermetically-sealed precision meter multipliers resistors.

Megomax hermetically-sealed high-voltage, high-temperature resistors.

**SPRAGUE ELECTRIC COMPANY, Resistor Division**  
(Formerly Sprague Specialties Co.) NORTH ADAMS, MASS.

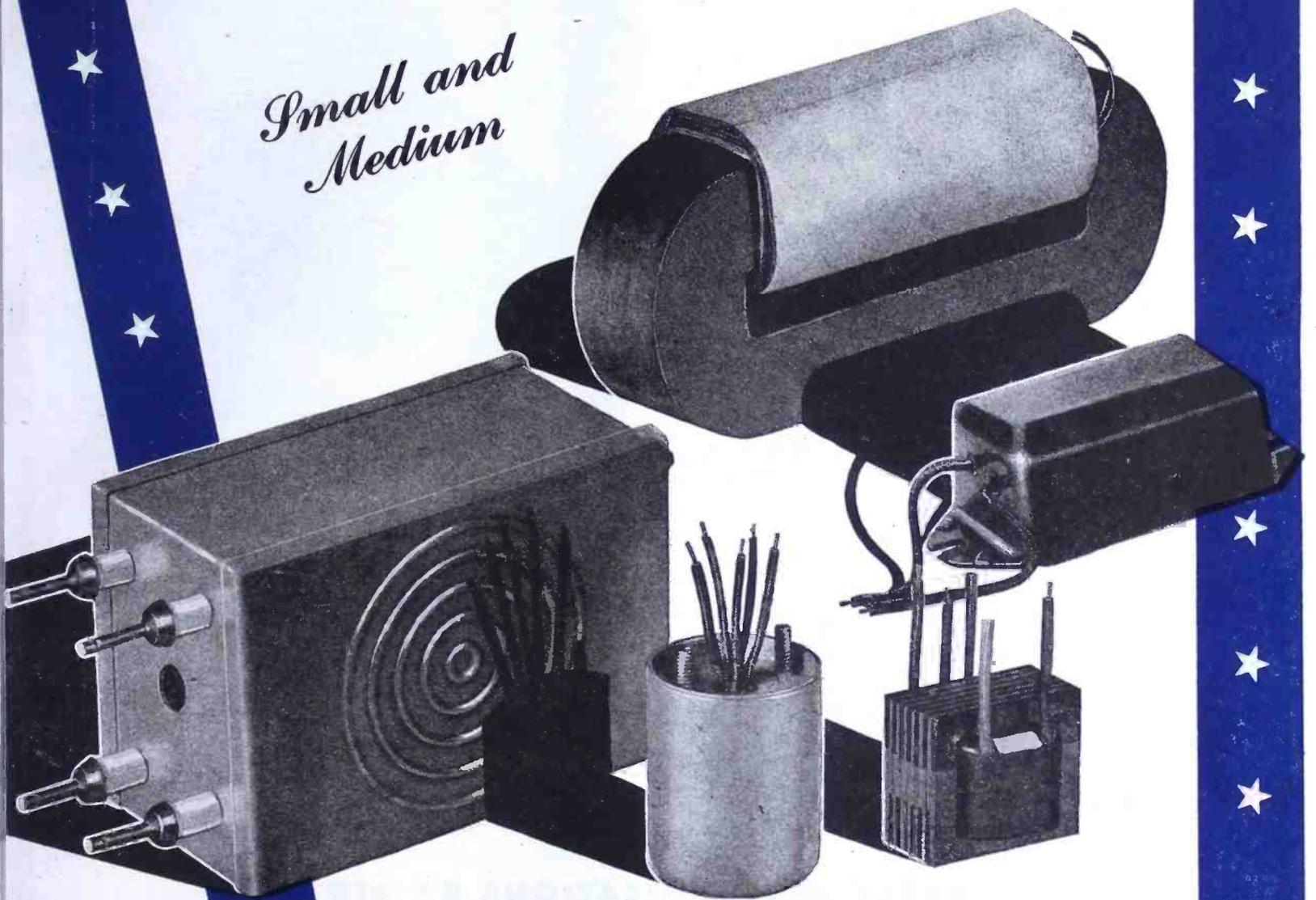


# SPRAGUE KOOLOHM RESISTORS

## The Greatest Wire-Wound Resistor Development in 20 Years

# TRANSFORMERS

*Small and  
Medium*



Control of all stages of production is the watchword at Consolidated Radio Products Company. That is why Consolidated's products can be depended on for quality, high efficiency, consistent performance and long life. International acceptance is the result of such high standards of production.

*Electronic and Magnetic Devices*  
**CONSOLIDATED RADIO**  
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350 W. ERIE ST., CHICAGO 10, ILL.



KEITH THOMAS

History of Communications Number Seven of a Series

## EARLY COMMUNICATIONS BY AIR



MODEL  
1700-UB

While electronics use the ether and other media, one of the most speedy methods of communications in the early days was through the air by carrier pigeon. With a finely printed note fastened to the leg, these birds faithfully reached home to bring in the latest news events and stock market reports.

Today news commentary reaches into your homes in a flash of a second via electronic voice communications making use of the various types of Universal broadcast microphones. This being a modern age, the battle front is brought into the homes of the informed peoples of the democracies via military microphones such as those now being manufactured by Universal for the Allied Armed Forces.

< Model 1700-UB, illustrated at left, is but one of several military type microphones now available to priority users through local radio jobbers.

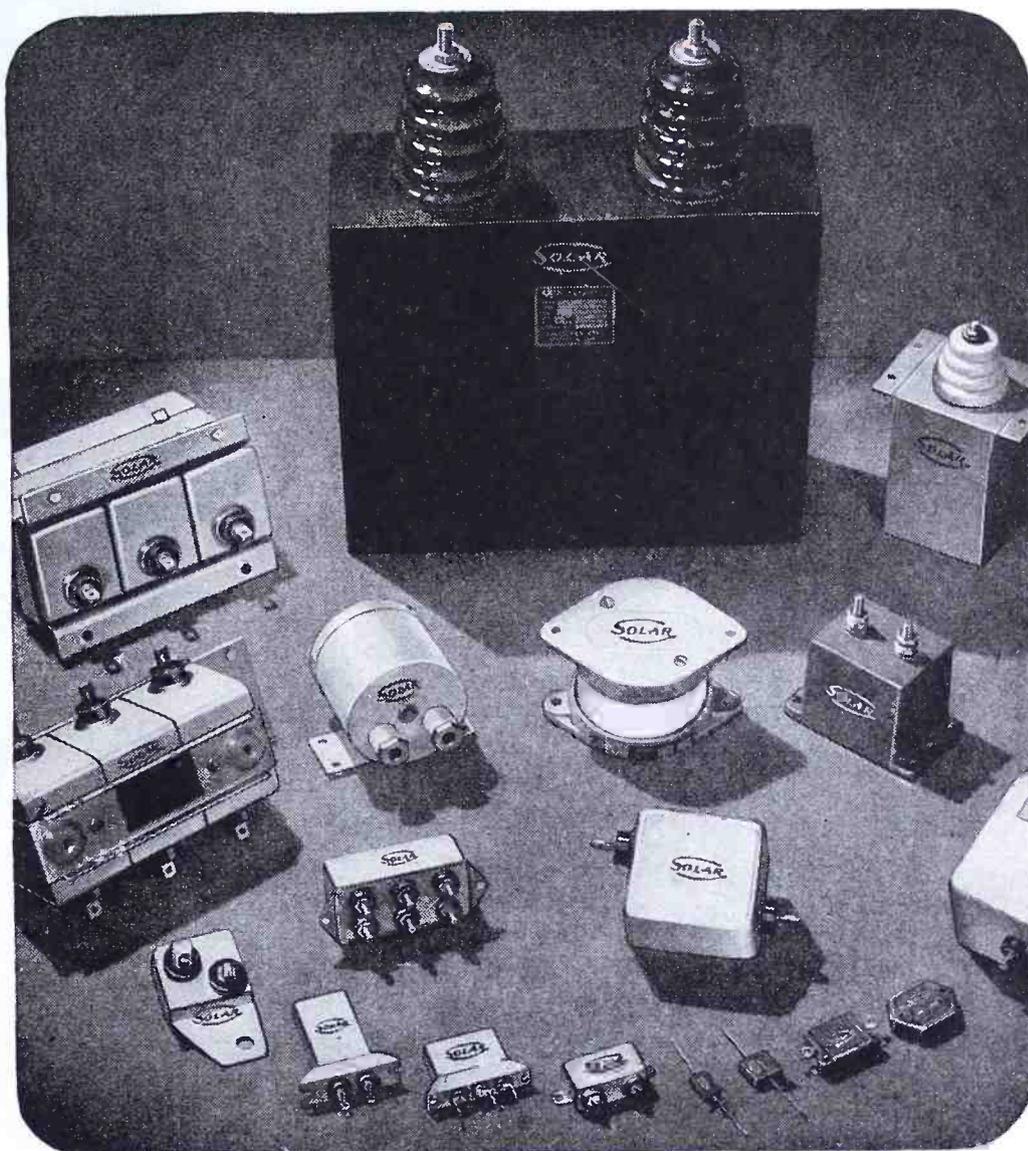


**UNIVERSAL MICROPHONE COMPANY**  
INGLEWOOD, CALIFORNIA



# These Solar Capacitors

## SERVE THE SERVICES



So you can see what they look like, they stopped to have their pictures taken, before going to war. They will serve with the Signal Corps, the Navy, with Ordnance vehicles and tanks; they will enable the Marines to tell it to each other; they will drop with paratroopers; they will visit every climate on the earth and will climb with the Air Force, above climate; they will win many merits even though they never wear them. Principally, they want you to remember, they will render an assist in the saving of many lives,—through reliable communications.

*Their story is told in pictures—including many official color photographs of troops in action . . . in a 40-page book "Solar Capacitors . . . in the War . . . in the Peace." Just fill out and mail the coupon.*

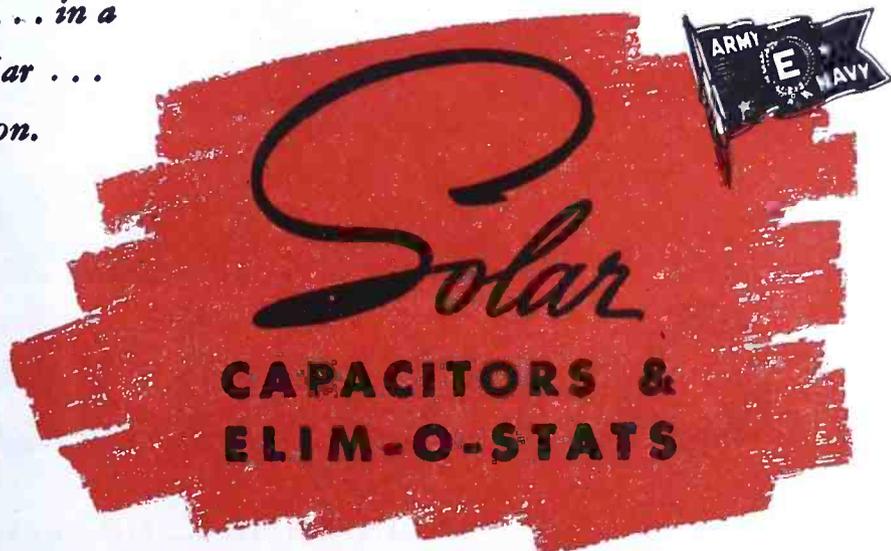
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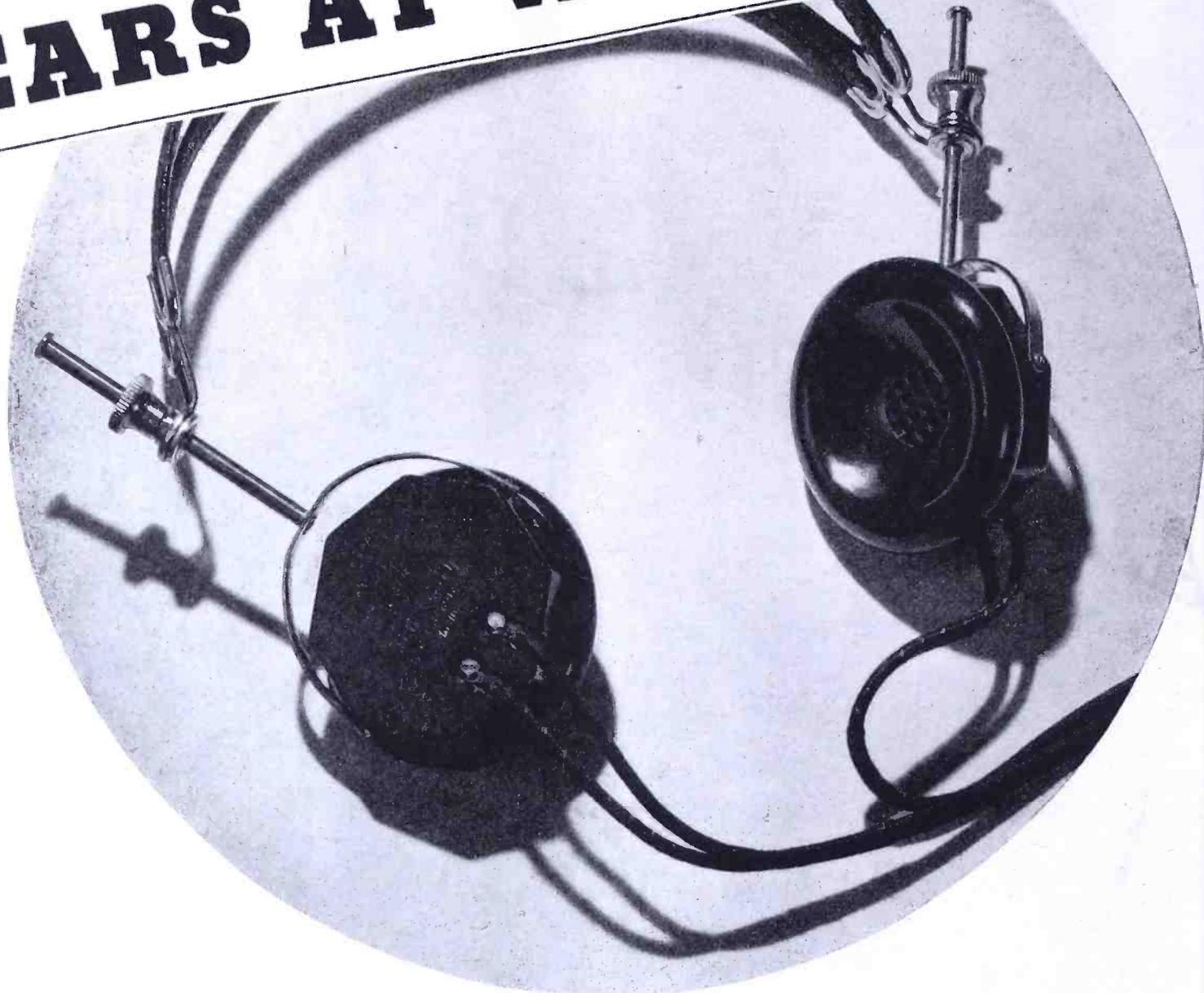
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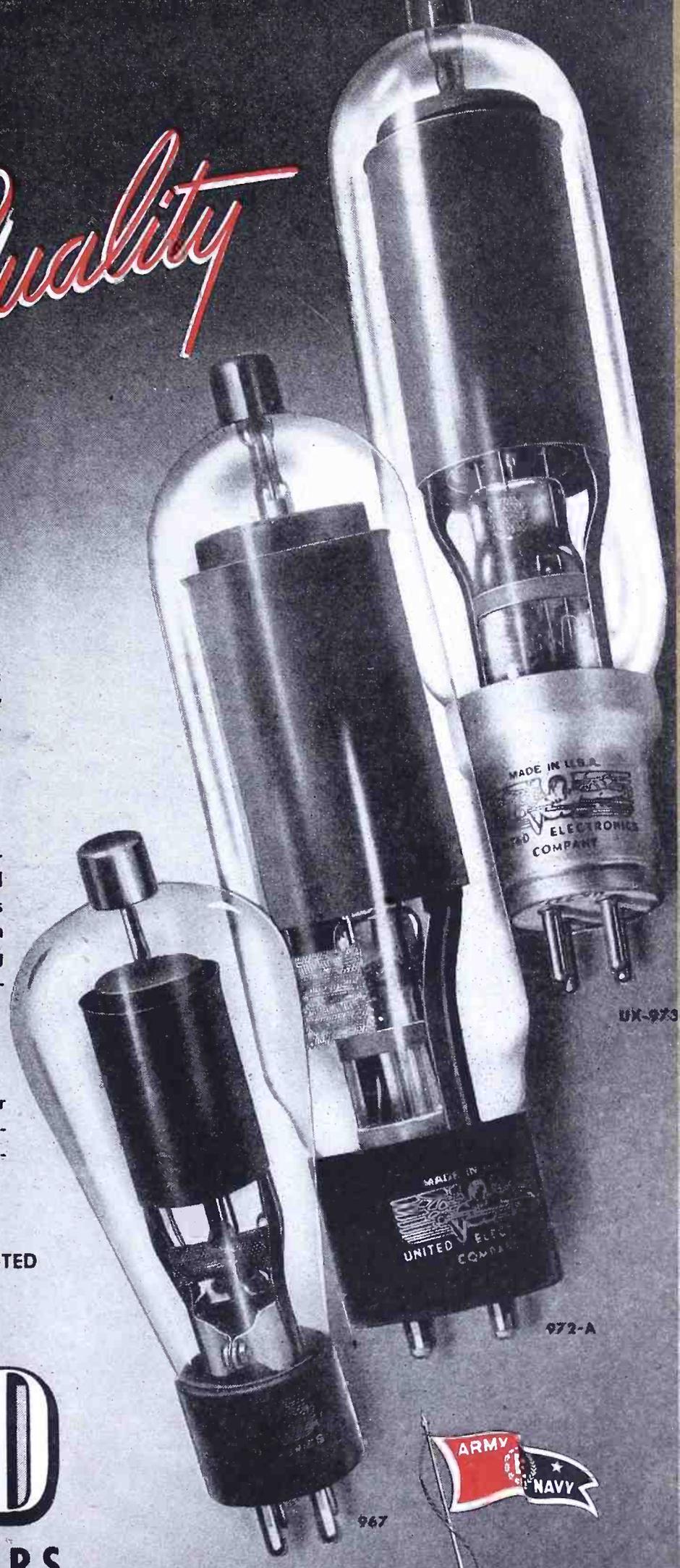
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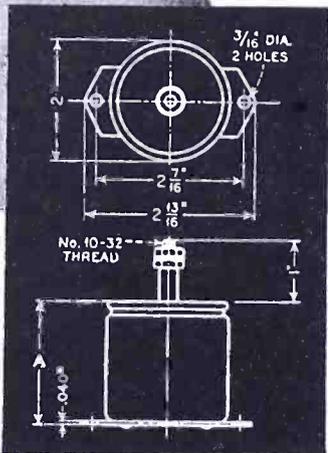
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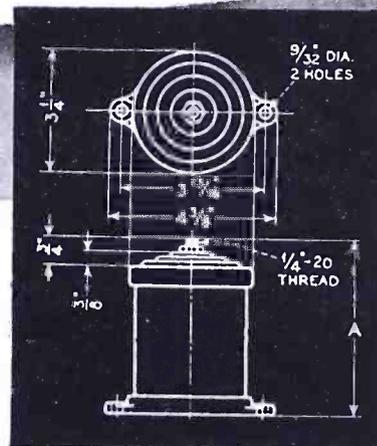
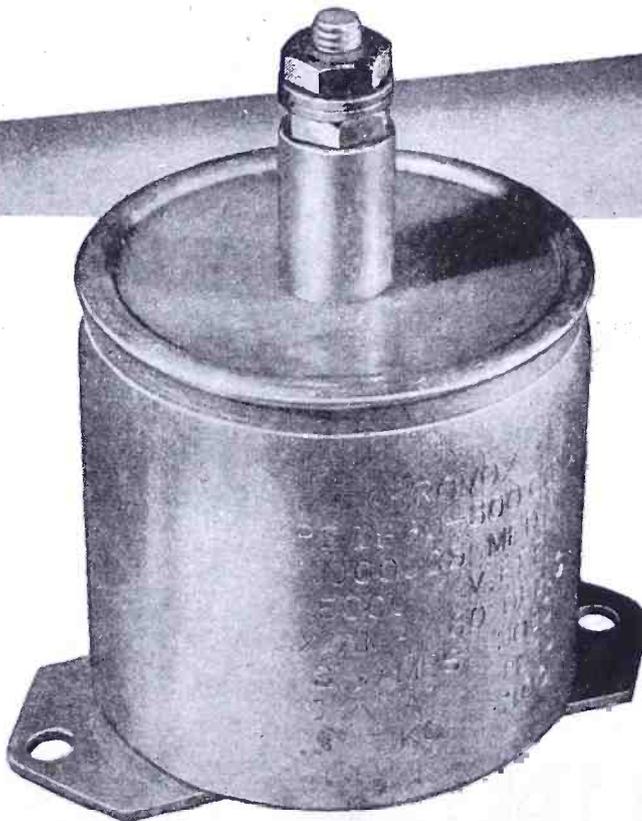
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Catalog lists maximum current in amperes at operating frequencies from 1000 KC. to 75 MC. max., for both types.



Type 1865 (no photo, but see drawing above) differs in the use of cast-aluminum case and steatite insulator to support terminal and withstand higher voltages. Dimension A is from 2-11/16 to 6-11/16"

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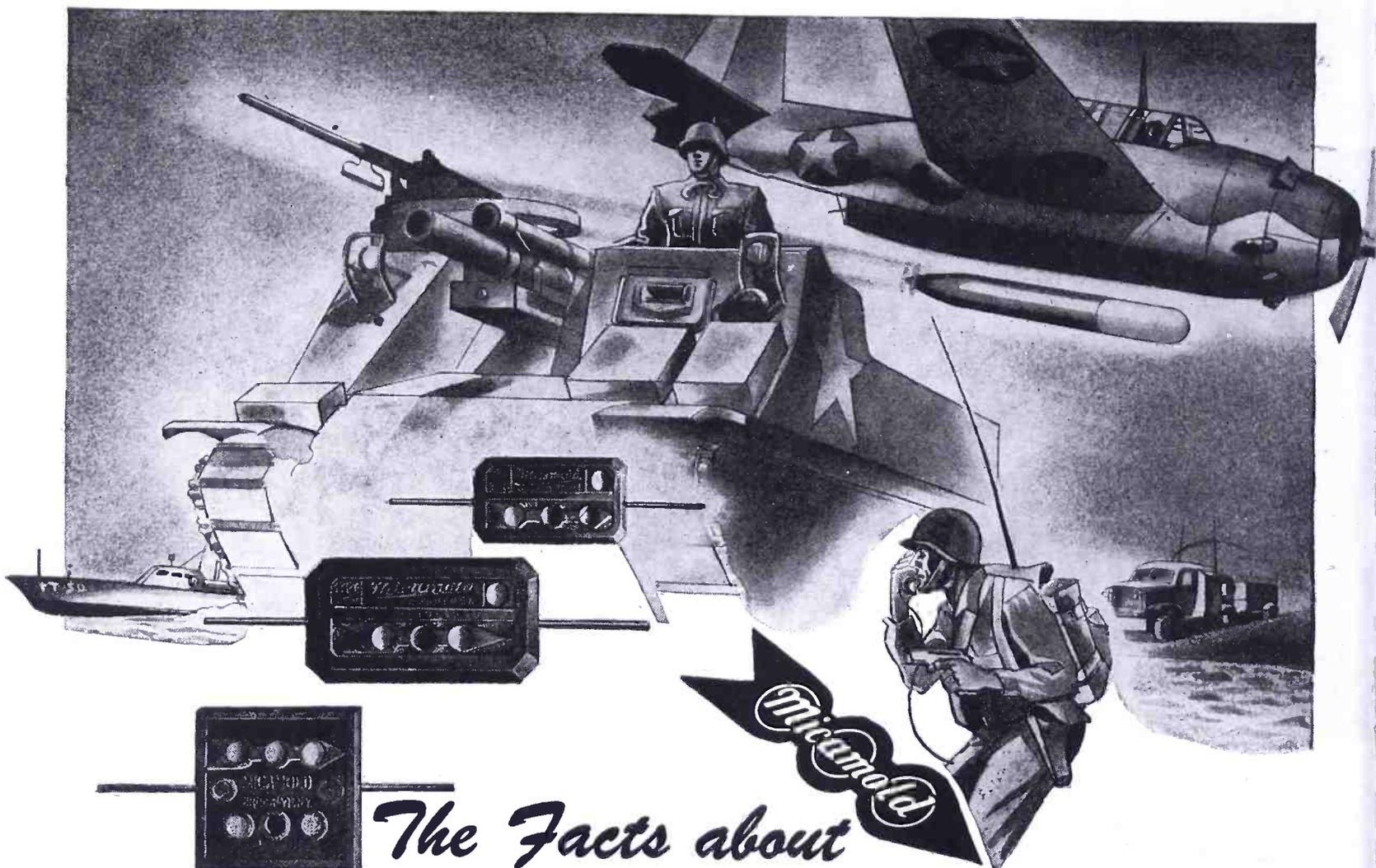


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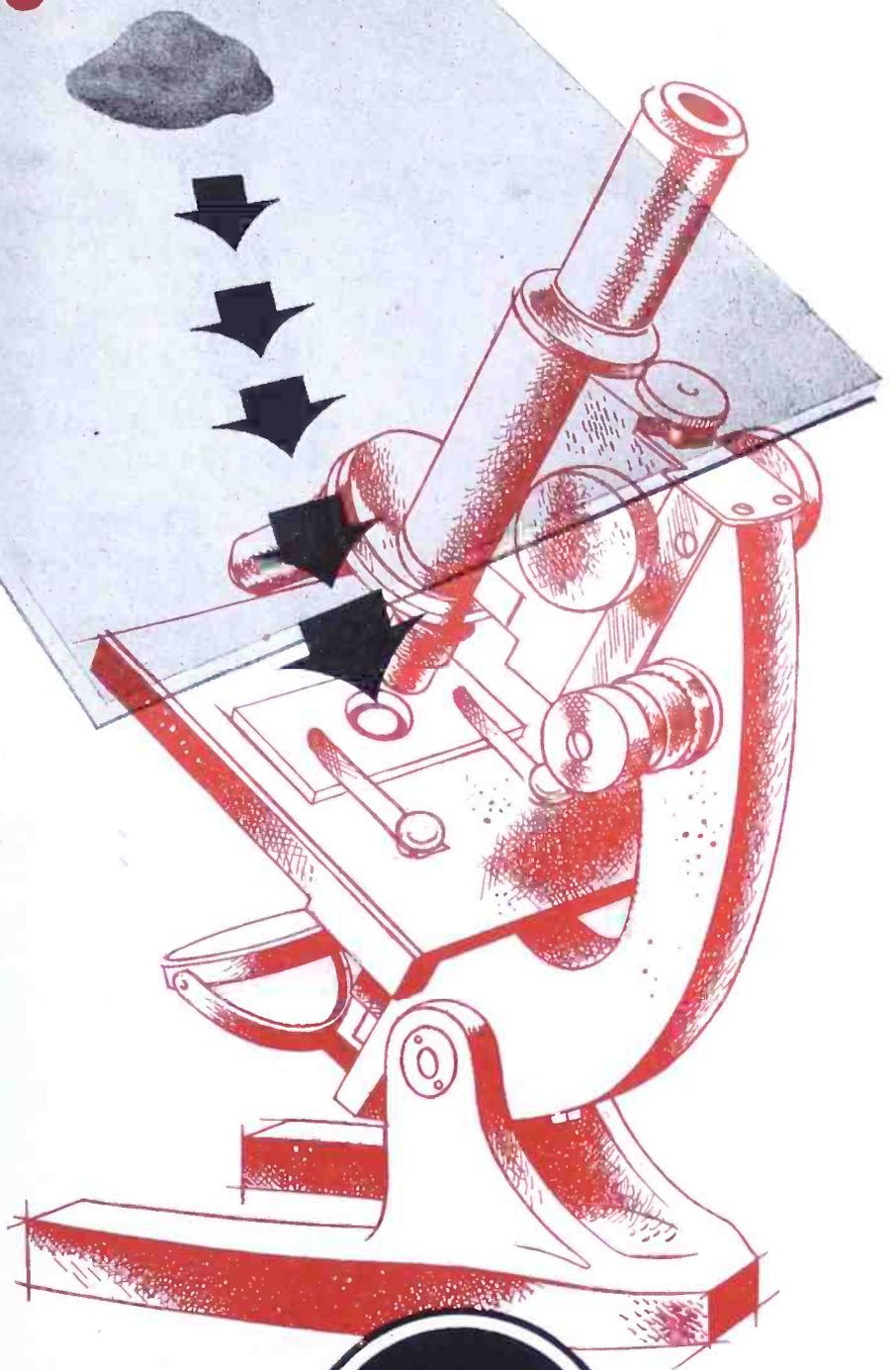
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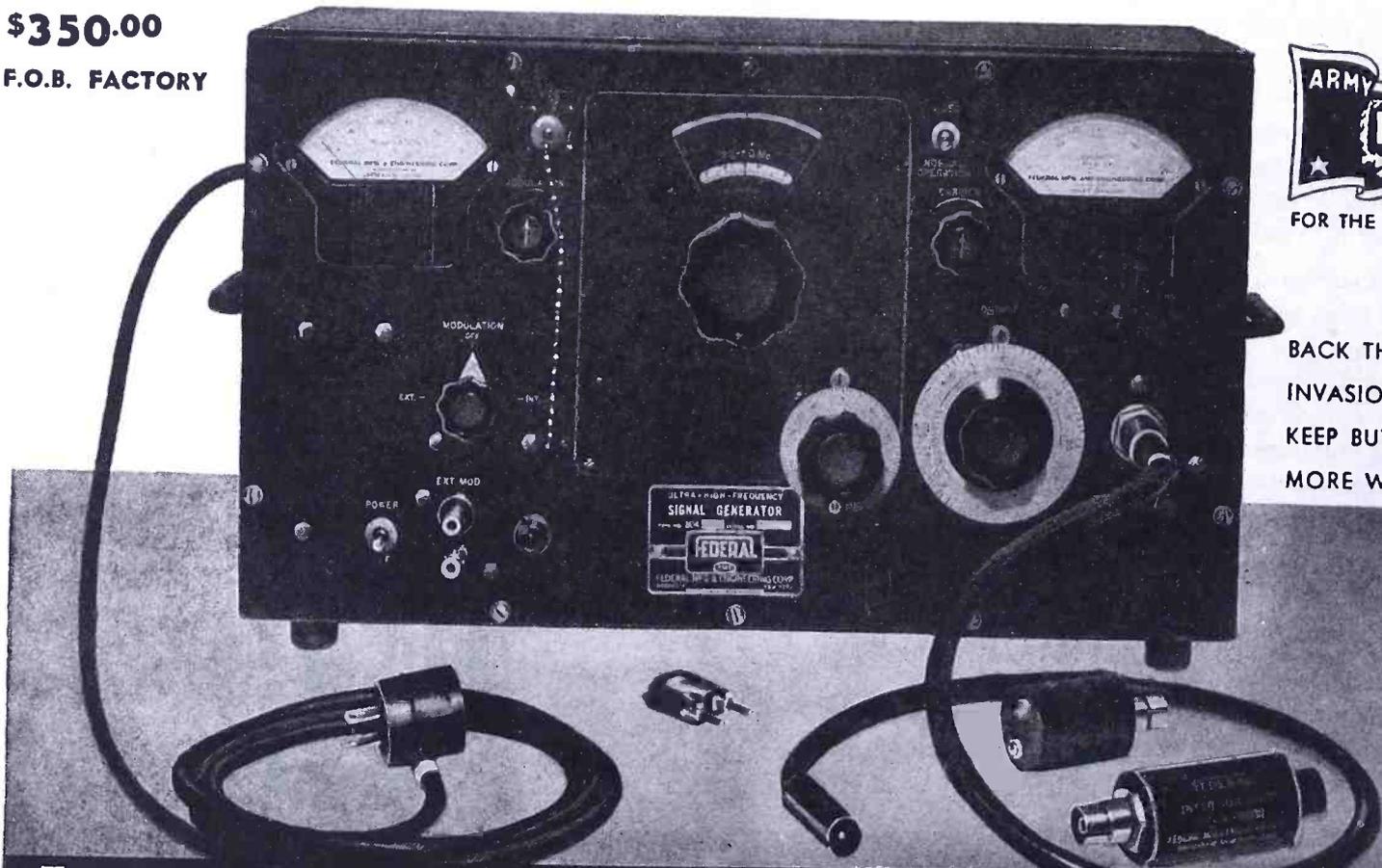
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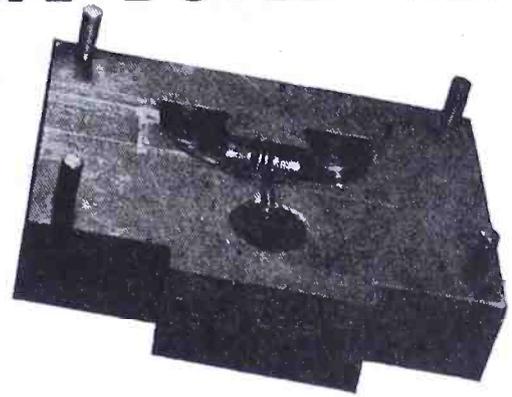
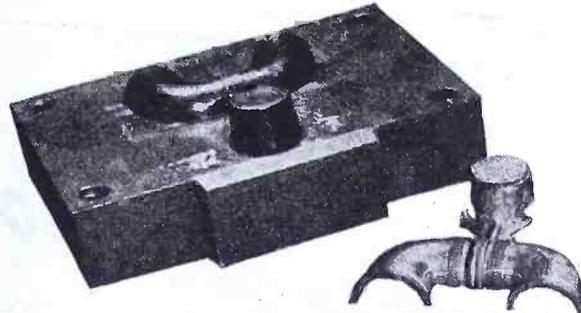
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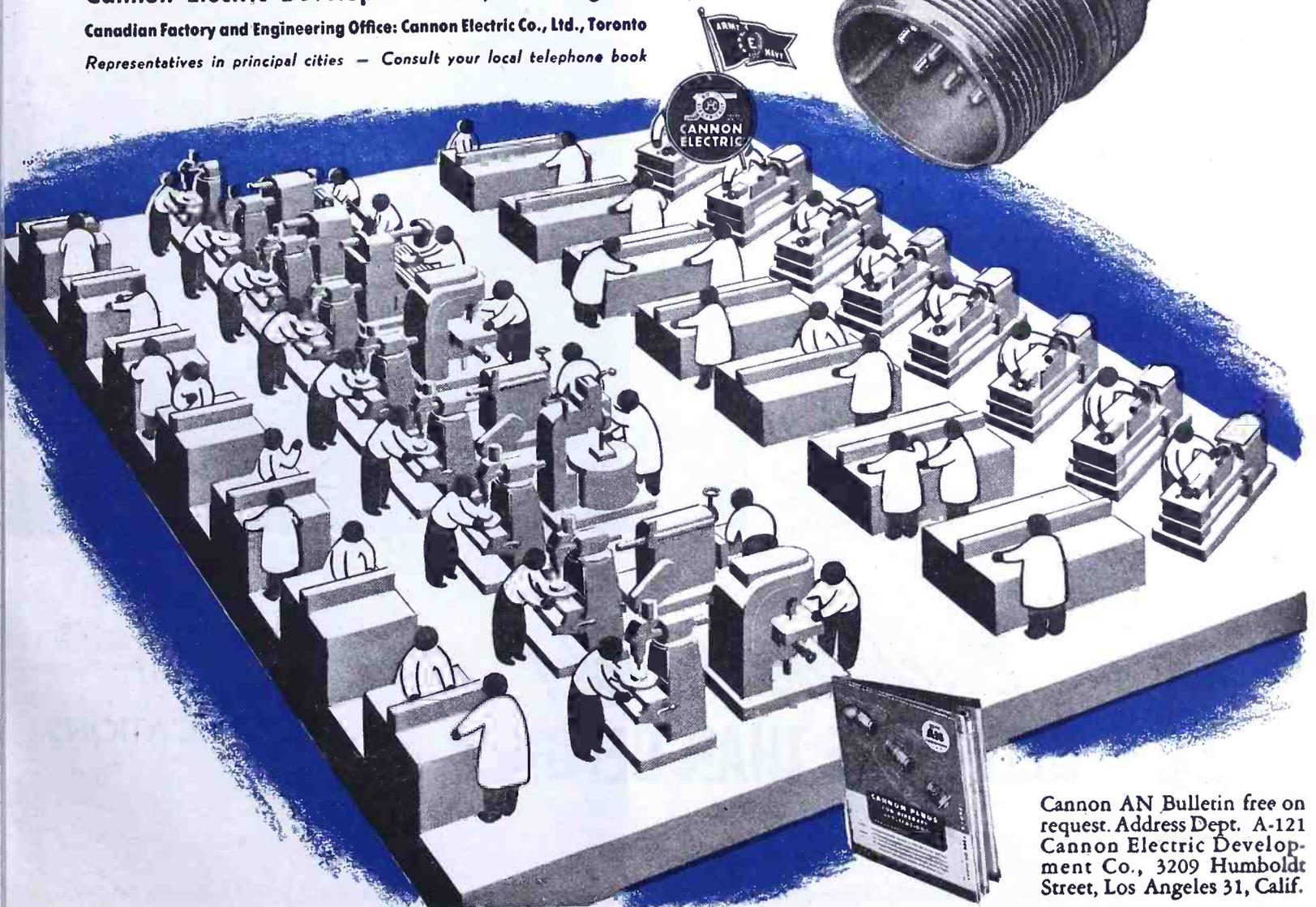
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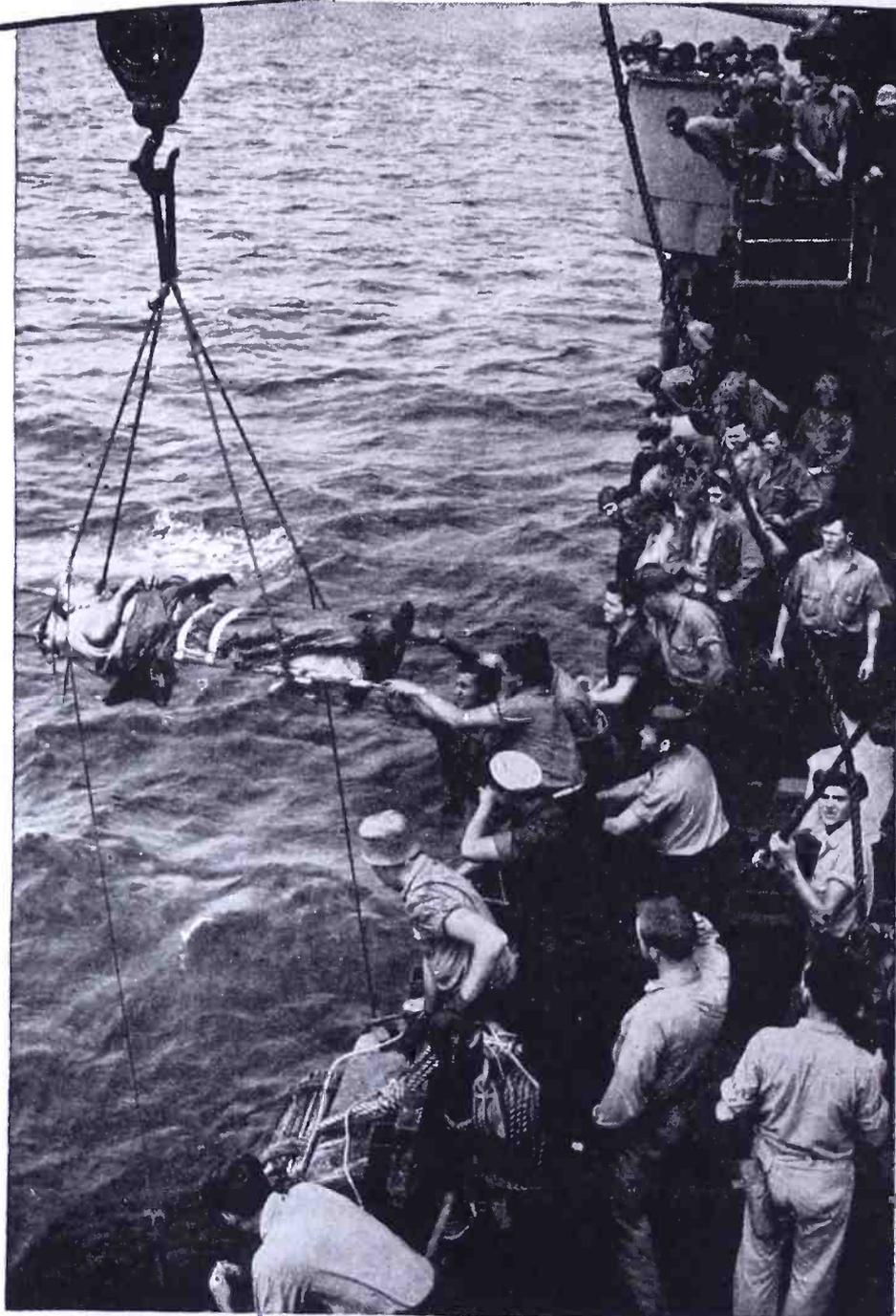
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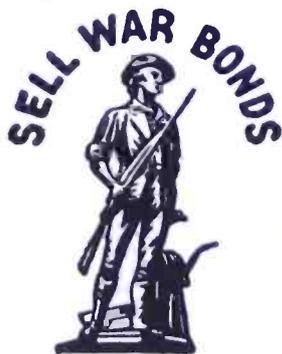
Decide now to revitalize your plant's Pay Roll Plan. Have your Bond Committee recheck all employee lists for percentages of participation and individual deductions. Have Team Captains personally contact each old and new employee. Raise all percentage figures wherever possible.

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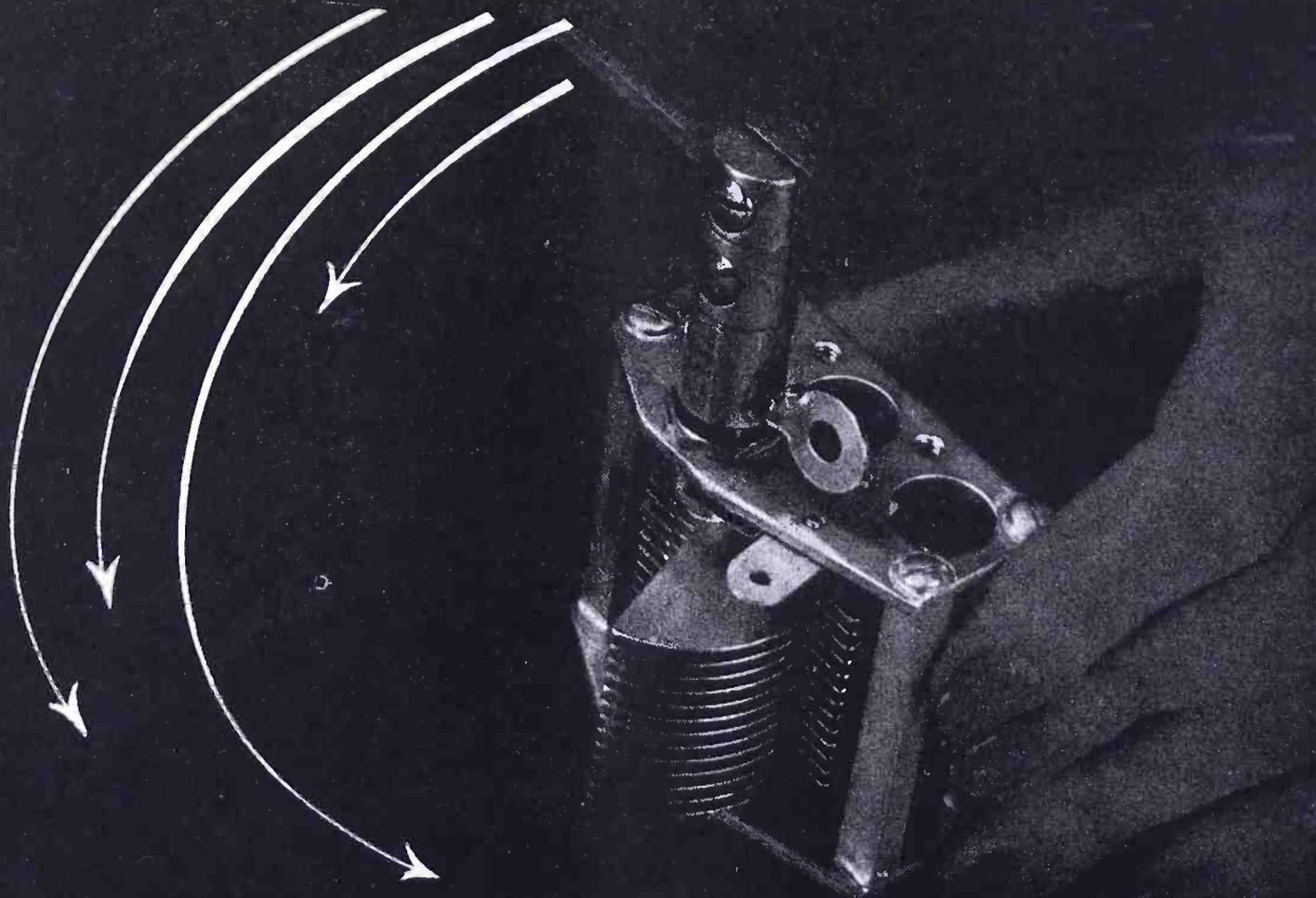
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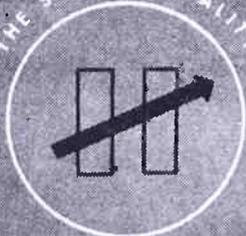


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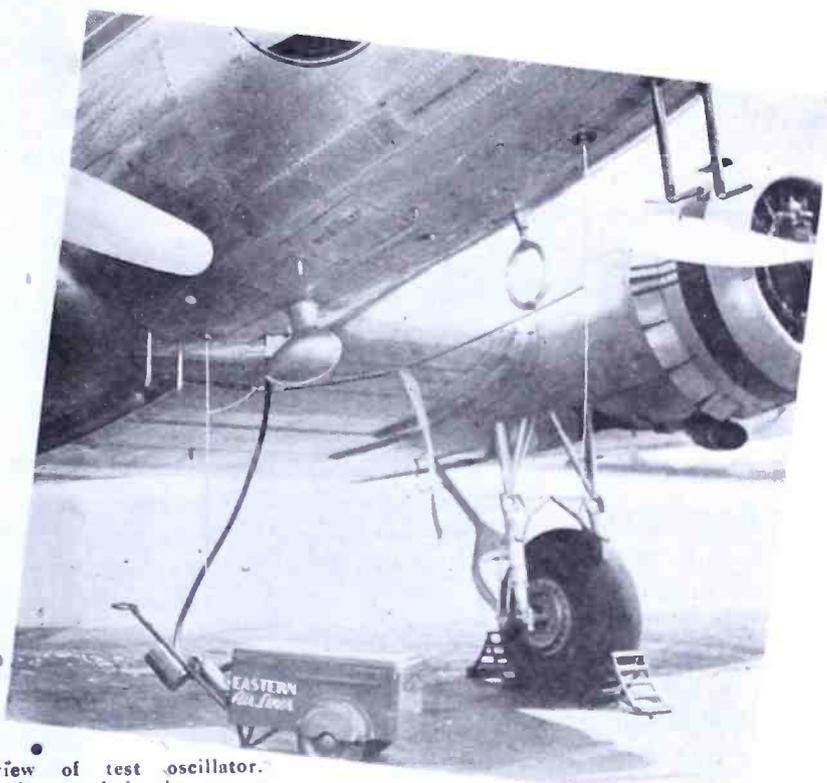
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# COMMUNICATIONS

LEWIS WINNER, Editor

AUGUST, 1944

right, a ground test installation (see Figure 2). The whip antenna located aft of the automatic radio compass streamlined loop is the sense antenna. The forward whip antenna during flight is used with the range receiver. During the ground radio compass test, it is used to connect the test oscillator to an external point where the "line" may be attached. The red flag attached to transmission line is a warning that precludes oversight of removing the "line" before departure. The external battery located in the cart shown beneath the plane is used for ground operation of radio equipment and its purpose is to conserve the plane's batteries.



External view of test oscillator. Located on the panel is the power "on-off" switch and r-f output jack. Clip shown at top left of case is used to attach oscillator unit to a bulb angle channel during test. Over-all case dimensions, excluding the clip, are  $6\frac{1}{2}$ " x 5" x  $2\frac{1}{4}$ ".

## PRE-FLIGHT INSTALLATION TESTS OF Automatic Radio Compasses

by CHARLES W. McKEE  
Supervisor of Aircraft Radio  
Eastern Air Lines, Inc.

This paper describes procedures used to make an overall check of an automatic radio compass installation aboard a plane. A test oscillator and the use of a left/right indicator meter to afford a means of comparison for calibrating oscillator output to the transmission line for a given  $\mu\text{v}/\text{m}$  field strength is described. A brief analysis of ground-effect symptoms that parallel those exhibited by malfunction of equipment is also presented. The purpose of the check procedure is to obviate these ground-effect conditions and to simulate *in-flight conditions*.

subjected to certain factors that introduce bearing errors. Such errors are

caused by various loop current effects. Their phase and magnitude are dependent upon shape and relation of metal aircraft structure.<sup>2</sup> For a normal radio compass installation on a given aircraft these bearing errors possess a constant characteristic; therefore, compensation can be applied for the necessary correction.<sup>3</sup> This is not always true when aircraft is on the service ramp or in the hangar. Under these conditions, radio bearings will usually present an error which may be plus or minus, a negative angle,\* and it may possess 180° ambiguity. The errors may be quite vari-

Figure 1, below  
 One method of installing the oscillator and transmission line for a pre-flight check of the automatic radio compass installed on aircraft. The oscillator is clamped to the metal pitot tube. The line is suspended on a center line with the loop antenna and connected to the aircraft metal structure which completes the test loop circuit. Because the action is that of a transmission line, it is imperative that a good electrical ground connection (to airplane structure) be made at points marked G.

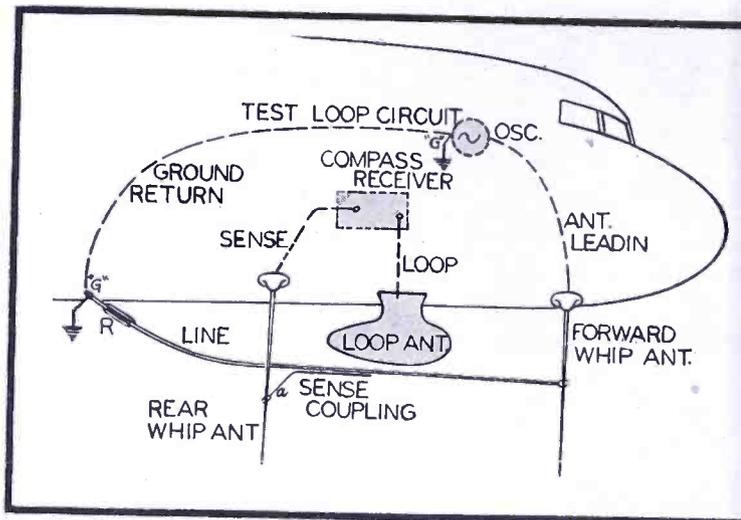
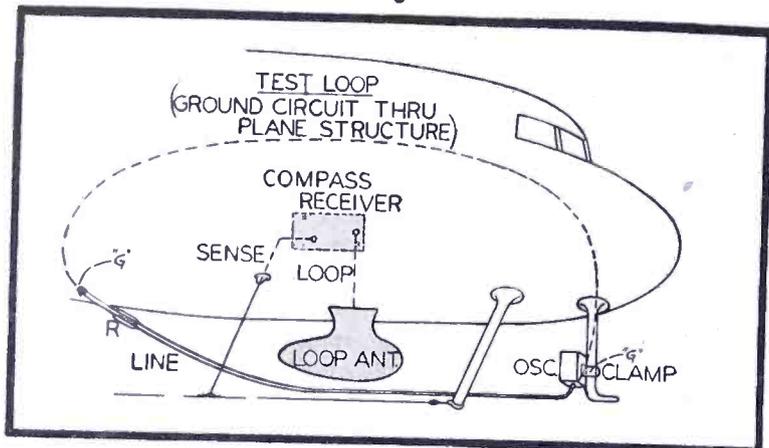


Figure 2  
 Another method of forming a test loop circuit. Here the oscillator can be located within the aircraft during the ground check. This is feasible when another antenna is available so that the oscillator output can be connected through the antenna lead in. Sense antenna voltage may be varied by adjusting capacity of sense coupling lead *a* to transmission line.

able due to metal objects in the immediate vicinity of the aircraft, such as work platforms, racks, ladders, carts and hangar structure. In addition, a grounding wire<sup>3</sup> attached to the wing or landing gear will in some cases result in giving bearings of 180° ambiguity or other erroneous bearings. (No test was made to determine the effects in this respect of graphite impregnated landing gear tires.) Bearing ambiguity may also be caused by an external battery cart cable placed adjacent to the sense antenna. A loop antenna located on top of the aircraft is not as susceptible to ground effect errors. An exception is when the plane is in a hangar and the metal structure ceiling is near the top loop antenna. Location of the aircraft in the clear of metal objects will reduce these ground errors to a negligible degree (except when taking a bearing on a station located directly on or nearly so of the aft line of the aircraft, for tail-down condition). Time economy during the servicing period of the aircraft does not always permit the *in-the-clear* location.

One method devised to make the overall-radio compass operational check without the aforementioned adverse ground conditions effects is to use a test transmission line scheme.<sup>5</sup> The basic arrangement of such a plan is shown in Figure 1. The test oscillator consists of an r-f source that is fed to a transmission line or a so-called test loop circuit. The latter is formed by a line preferably placed longitudinally and spaced outward from the radio compass loop antenna.

<sup>5</sup>The term *negative angle* is applied to describe the condition where the normal angle of indication is displaced by an angle of equal amount on the opposite side of the center line of the aircraft.

The line is not shielded and can be across any two fixed terminal points that will place the loop antenna center directly between line and the shield (ground). Its corresponding azimuth angle is used as a reference. Should we find the amount of sense voltage incorrect, it is only necessary to change the coupling between the *line* and the sense antenna. Thus an excessive value of sense voltage will be avoided.

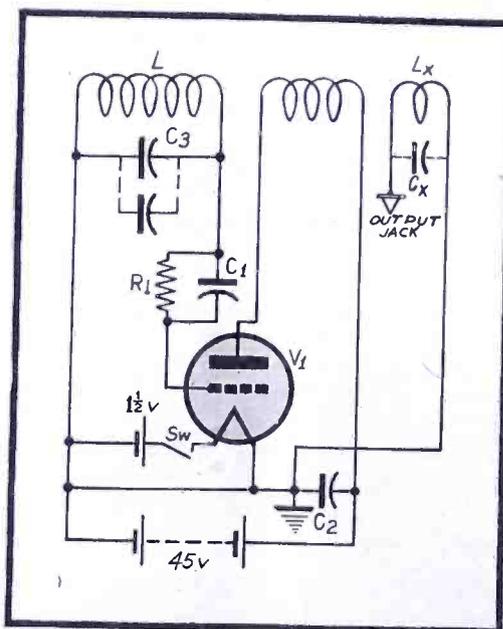
It is important to have good electrical ground contact at the oscillator and the *line* terminating point to obtain normal transmission line function. When other than a *line* is used, the

reception of the oscillator radiation presents a possibility that bearing will be subjected to ground-effect errors.

Certain antenna installations readily lend themselves to a more convenient arrangement for a setup of the transmission line. One such arrangement is illustrated in Figure 2. The test circuit *line* is formed by connecting the test oscillator output to the forward beacon-antenna lead-in. The voltage will appear on the forward whip type antenna when the antenna switch is in the *beacon-antenna* position. The loop circuit is completed by use of a *line* attached to the forward whip antenna. The other end of the line is connected to ground (at a point on the aircraft structure) through a 400-ohm resistor. This is located at the end of the line at the grounded point. The radio compass loop antenna is located within the test oscillator loop circuit. The lead designated *a* serves to introduce sense voltage from the test loop to the sense antenna.

The oscillator, operating within the 200-400-kc band, is used as a source of r-f. After the output calibration is completed and the second harmonic output is found to be of sufficient value, we have a check on the number *two* band of the receiver. It is not essential that both bands be checked because the compass loop, sense antenna and autosyn circuits are common for both bands. However, in case of interference on the fundamental, the available use of the second harmonic is an advantage. The oscillator, for obvious reasons, was designed to be compact, light weight and to include the power supply. For sake of simplicity, no

Figure 3  
 Conventional oscillator circuit operating at 300 kc to provide the r-f signal for ground test.  $V_1$  is 1E4G tube or equivalent;  $C_1$  and  $C_2$ , .0001 mfd;  $C_3$ , .002 mfd; and  $R_1$ , 0.1 megohm. Inductance  $L$  is 3 mh,  $L_x$  is one to two turns, coupling to the load,  $C_x$  value is to be determined and depends upon the desired attenuation of r-f output.



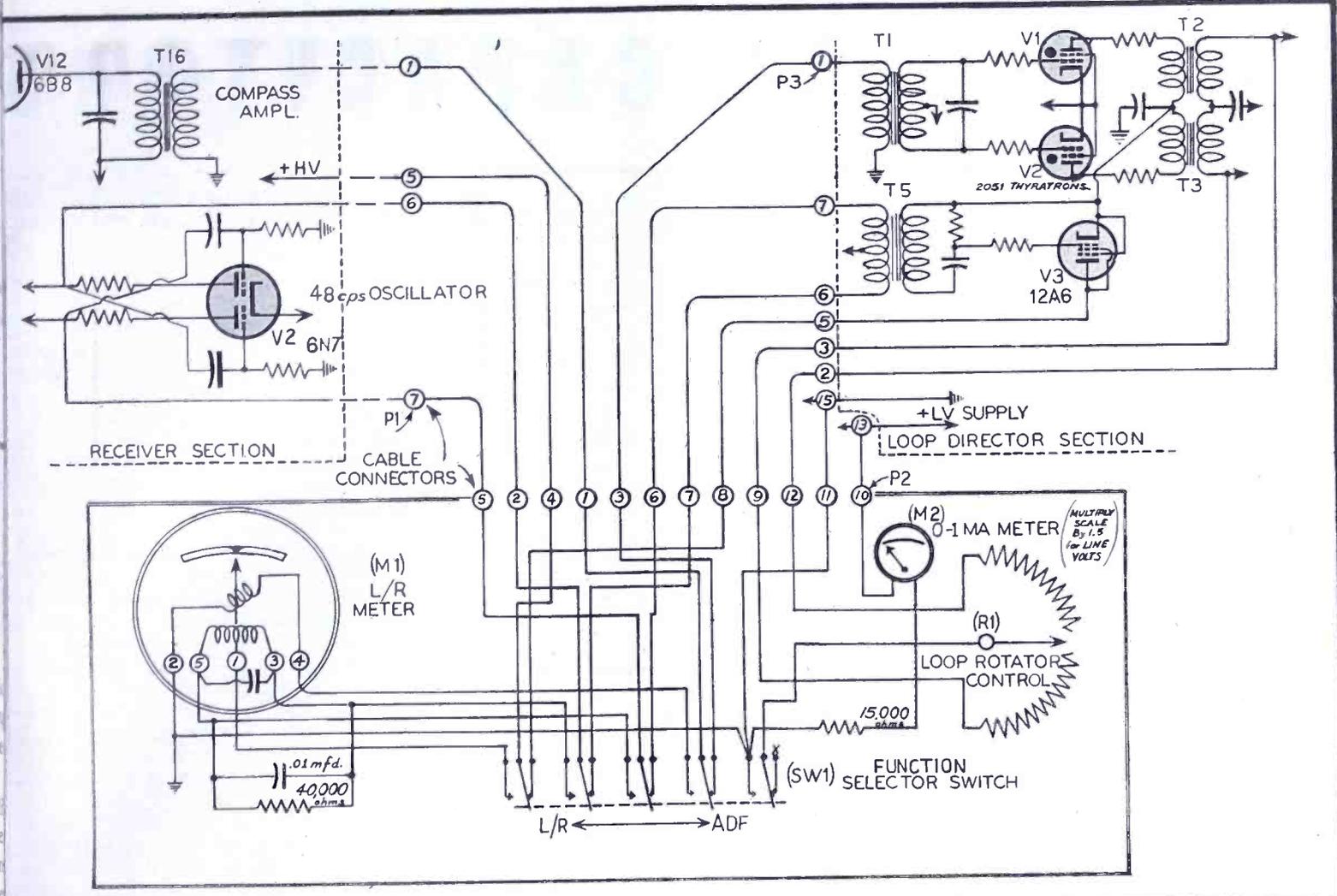


Figure 4  
 Circuit of *l/r* test instrument and a section of the MN31 compass relating to the test device. Plug pins of P1 and P3, one through nineteen, not diagrammed, are not intercepted in adaptor cable. They are connected direct, in accordance with MN31 circuit. Exceptions are the tapped circuits; 13 and 15 pins.

modulation is provided. This is permissible when a beat frequency oscillator is included in the compass receiver.

Shown in Figure 3 is a conventional oscillator circuit used for the test model. For sake of compactness and simplicity, a fix-tuned type oscillator was used for the model to conduct the test to check this procedure. To avoid radio interference, a clear channel within the band was selected for the ground location involved. To select frequency suitable for the test location, we made provision for padding, a 10-mmfd padding condenser. This provides a decrease in frequency of approximately 10 kc. An adjustable on-core inductor could be used instead of the condenser padding to affect frequency change, and it would not necessarily add to space requirements. A wide tuning range would affect the r-f output of the test oscillator. Should this frequency change be great enough, it would cause a corresponding change in the oscillator output level which would affect the calibration. The oscillator metal case construction provides access to batteries for check and replacement. This is important because accuracy is affected when battery voltages are below permissible limits. (The model described was found by actual performance test to operate normally with

battery limits of *B* voltages, 45 to 35, and *A* voltages, 1.5 to 0.8.) These values were those measured under load. In connection with this subject, there is a point well known, but merits mentioning; that is, the variations of the r-f oscillator output that can be tolerated are dependent upon the receivers overall automatic gain control characteristics. A larger variation is permissible without detrimental effects when operation is at the threshold (or knee) of the signal input versus 48 cps modulated output curve. Conversely the limits are very narrow when the oscillator signal level is of such value that it operates below the knee of the curve.

An analysis of the involved circuit function of the *l/r* compass and automatic compass differences, will show that for a quantitative comparison check in the field the oscillator output and transmission line coupling must not be excessive. This is because the gain of the loop amplifier stage of the automatic radio compass is controlled by

avc rectified from the compass amplifier stage. It is factual that the linear relation between the *l/r* meter deflection and signal input will flatten out at the point when the overall avc characteristics limits the 48 cps side-band modulation in the receiver. However, for general qualitative checks and fault isolation purposes the oscillator output and sense r-f coupling need not be accurately calibrated and a wider battery voltage can be tolerated.

Compliance with simplicity requirements require the omission of an adjusted type of r-f output attenuator. This of course eliminates attention that would be required for such an adjustment. Oscillator r-f output power is calibrated to a pre-set value within the required limits to give the approximate  $\mu\text{v/m}$  field strength at the loop antenna as used in the screen room.

The value used is that which is comparable to a minimum signal encountered in service.

The value of sense voltage introduced from the transmission line (of the test loop) is a function of the degree of coupling, referred to in Figure 2. Relation of sense antenna voltage to the loop antenna voltage determines the degree of 48 cps modulation. A reference base for their relation is given as a field strength of 1,000  $\mu\text{v/m}$  at the loop antenna and a vertical an-

(Continued on page 64)

# FIXED MICA CAPACITORS

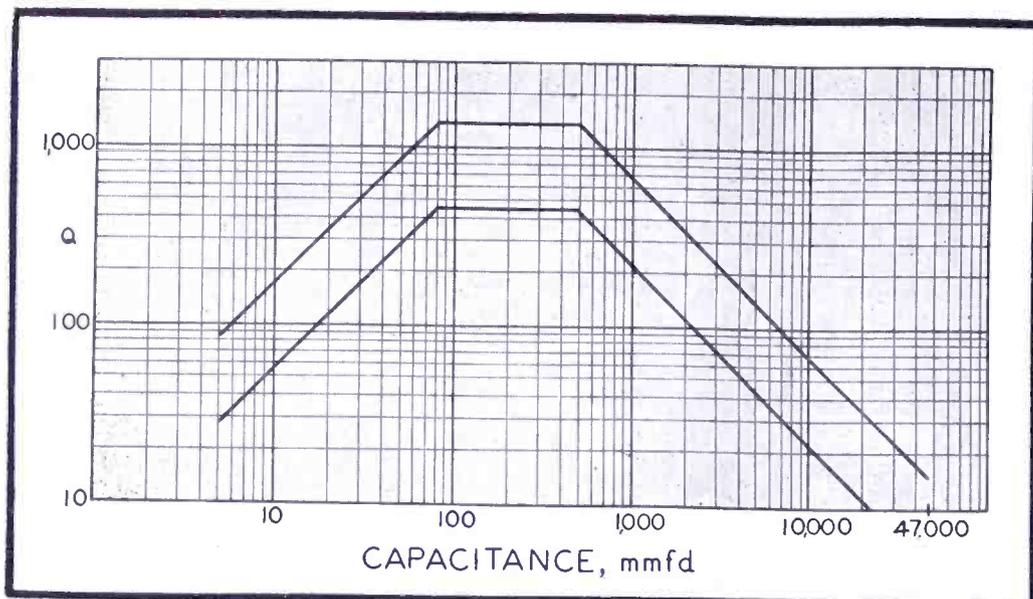


Figure 1  
Capacitance and  $Q$  at 1 megacycle.

STANDARDIZATION of fixed mica-dielectric capacitors under Joint Army-Navy Specification JAN-C-5 has brought about a changing supply situation in which *standard* mica capacitors can now be procured more easily than the *non-standard* units they replace.

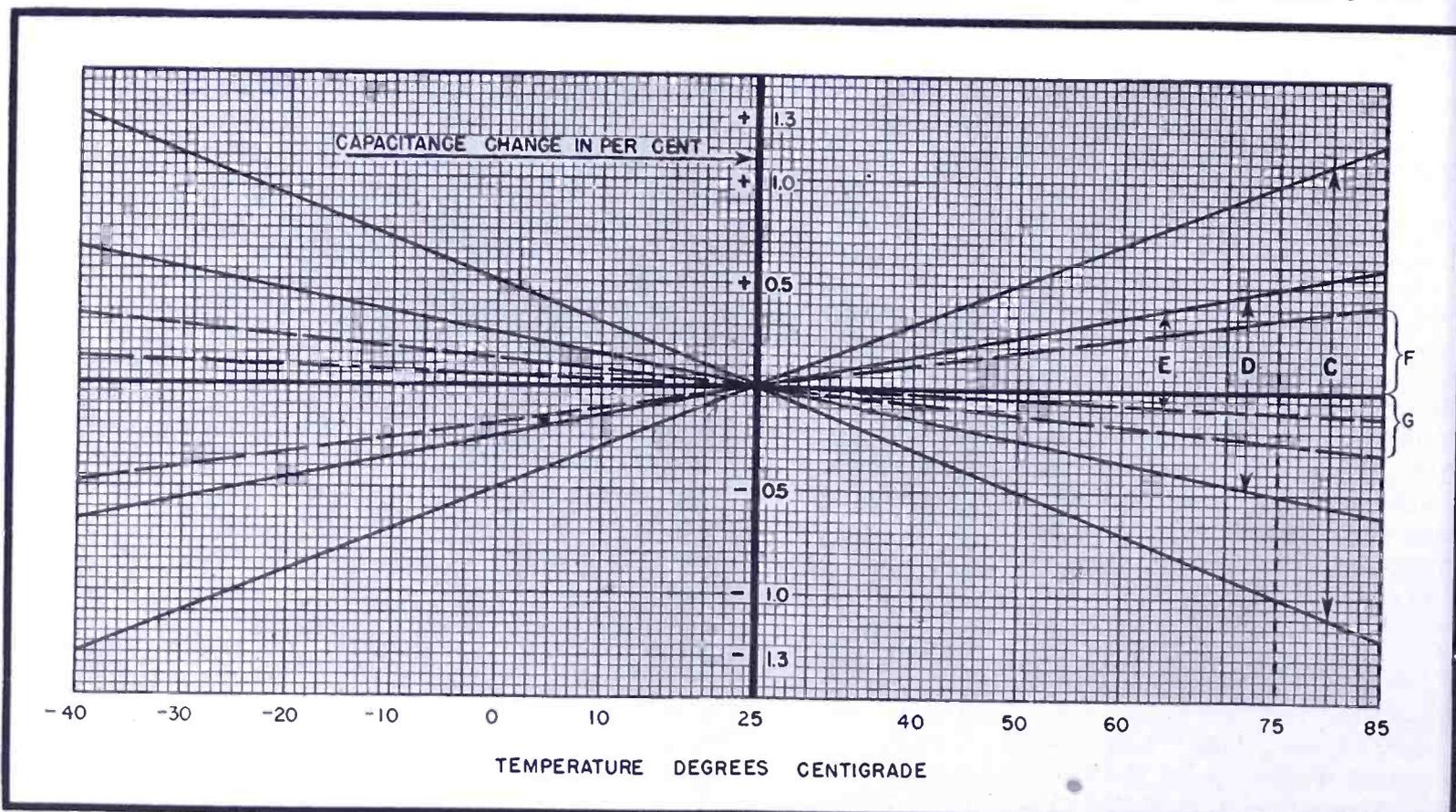
Anticipating the time when the majority of orders will call for *standards*, capacitor manufacturers have geared to *standard* types and are urging that all orders, wherever possible, be converted to *standards* so that production facilities, made available through *standardization*, may be utilized.

Demonstrating the manufacturer's capability of meeting the requirements of the mica capacitor *standard*, approximately 75% of the industry's output is now backed by Qualification Approval. Additional approvals are expected to raise this

percentage as *qualification testing* proceeds.

JAN Specification C-5, in addition to specifying general requirements, is actually a comprehensive catalog of *standard* capacitors. The various physical and electrical sizes, each with its own *standard* type designation, are designed to meet practically all applications. The standard

Figure 2  
Limiting curves of temperature coefficients listed in table 1 of pro JAN C-5 specification.



is not intended to cover the few cases where special values and tolerances are essential to the performance requirements of critical circuits.

## Case Sizes

Standardization of physical sizes has been achieved by establishing maximum dimensions for several case sizes: *CM20*, *CM25*, *CM30*, etc. (See voltage table for complete listing of *CM* numbers.) The dimensions for each are given in the detailed drawings of Specification JAN-C-5.

## Characteristics

Requirements of the present war dictate that military equipment must be capable of maximum performance at all times regardless of variations in climatic conditions. The war in the air, at ever increasing altitudes, has brought about even more severe conditions.

To meet the requirements for various grades of mica capacitors, letters have been assigned corresponding to the characteristics necessary for proper application.

Characteristic *A* is usually satisfactory for most applications where temperature coefficient and  $Q$  are not critical. The lower curve of Figure 1 shows the minimum values of  $Q$  for *A* characteristic mica capacitors.

Characteristic *B* is also satisfactory where a definite temperature coefficient is not essential but where a higher value of  $Q$  is desired. The upper curve of Figure 1 shows the minimum value of  $Q$  for characteristics *B*, *C*, *D*, *E*, *F* and *G*. Figure 1 does not apply, however, to those capacitors listed in the *Standard* having specific r-f current ratings.

Characteristics *C*, *D*, *E*, *F* and *G* are used in applications requiring definite

# SIN THE ARMY-NAVY ELECTRONICS

## Standardization Program

by **GEORGE A. OSMUNDSEN**

First Lieutenant, U. S. Signal Corps  
Assistant Chief Standards Application Staff

limits of capacitance-change with temperature. The temperature coefficient in parts per million for each of the characteristics C, D, E, F and G are as follows:

| Characteristic | Temperature Coefficient parts/million/degree C |
|----------------|--|
| C              | ± 200  |
| D              | ± 100  |
| E              | - 20 to + 100                                  |
| F              | 0 to + 70                                      |
| G              | 0 to - 50                                      |

(parts per million per degree Centigrade may also be thought of as micromicro-

farads per microfarad per degree Centigrade)

### Silvered Micas

Capacitor manufacturers are able to meet these higher requirements through the use of silvered mica, together with suitable aging processes to stabilize the capacitor at the desired characteristic. In general, mica capacitors have a positive temperature coefficient; that is, the capacitance increases with increase of

temperature. The negative characteristic G is available only in the larger transmitting types and is obtained through the use of ceramic dielectric sections in combination with mica sections.

The mica capacitor temperature coefficient chart (Figure 2) is a graphical representation of the temperature characteristics C, D, E, F and G. Parts per million per degree Centigrade have been converted to percentages corresponding to temperatures over the range -40° C to + 85° C. 25° C is the normal or reference temperature from which all temperature changes are calculated. Thus

(Continued on page 90)

Table 1

Voltage Ratings of Jan. Specifications C-5 Fixed Mica-Dielectric Capacitors

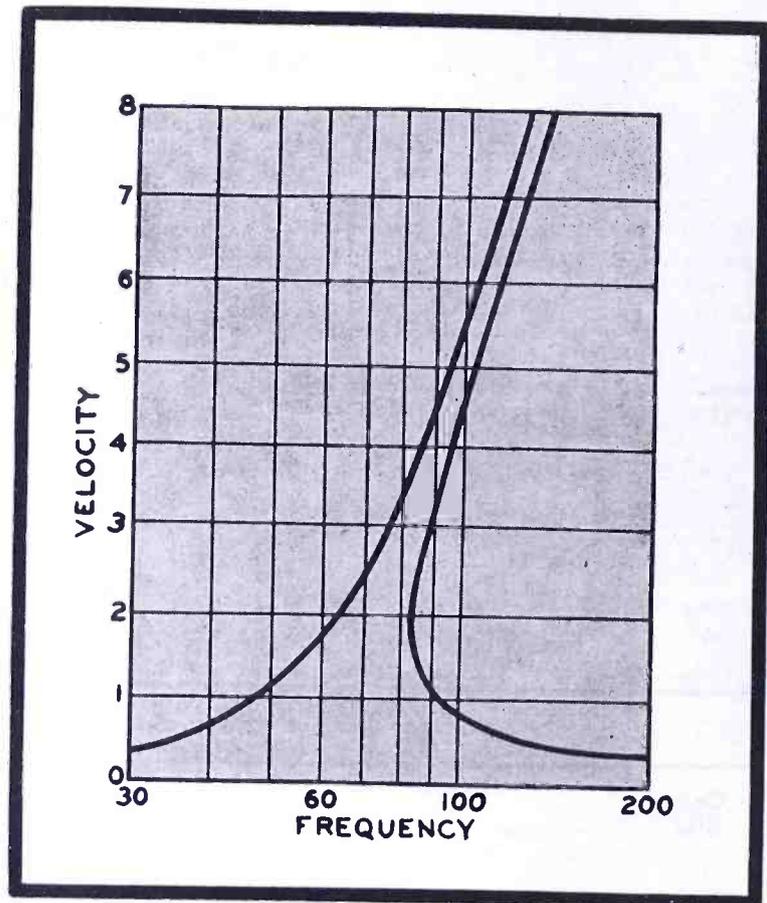
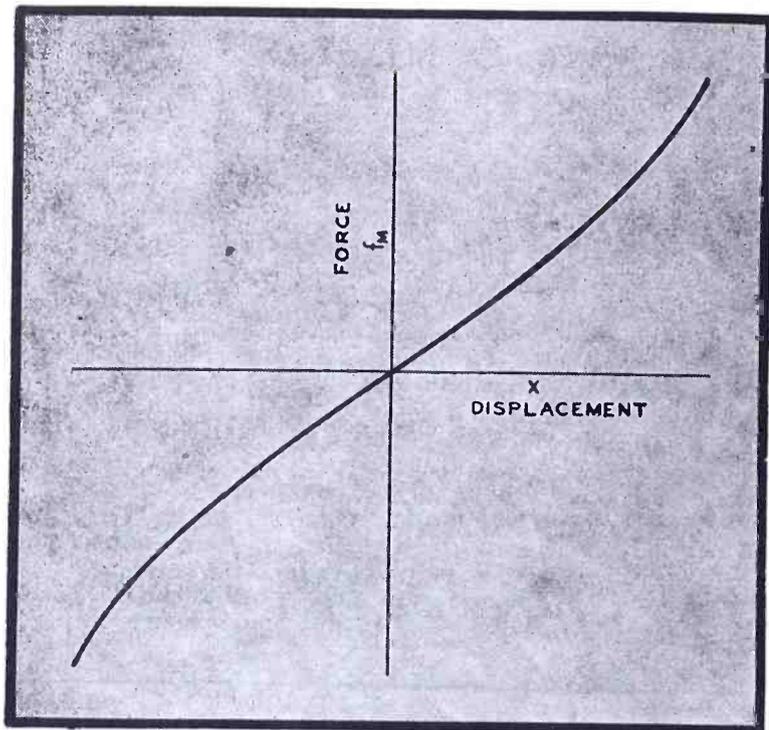
| Case Size | Capacitance mmfd |       |        | DCWV | Case Size | Capacitance mmfd |       |        | DCWV  |
|-----------|------------------|-------|--------|------|-----------|------------------|-------|--------|-------|
|           | From             | Above | Up To† |      |           | From             | Above | Up To† |       |
| CM20      | .....            | ..... | 510    | 500  | CM80      | .....            | ..... | 2000   | 10000 |
| CM25      | .....            | ..... | 1000   | 500  | .....     | .....            | 2000  | 4300   | 8000  |
| CM30      | .....            | ..... | 3300   | 500  | .....     | .....            | 4300  | 5100   | 6000  |
| CM35      | .....            | ..... | 6200   | 500  | .....     | .....            | 5100  | 11000  | 5000  |
| .....     | .....            | ..... | .....  | 300  | .....     | .....            | 11000 | 16000  | 4000  |
| CM40      | 3300             | ..... | 8200   | 500  | .....     | .....            | 16000 | 27000  | 3000  |
| .....     | .....            | 8200  | 10000  | 300  | .....     | .....            | 27000 | 68000  | 2000  |
| CM45      | .....            | ..... | 1800   | 2500 | .....     | .....            | 68000 | 100000 | 1500  |
| .....     | .....            | ..... | 3600   | 1200 | CM85      | .....            | ..... | 1100   | 20000 |
| .....     | .....            | ..... | 10000  | 600  | .....     | .....            | 1100  | 2000   | 15000 |
| CM50      | 2000             | ..... | 5100   | 2500 | .....     | .....            | 2000  | 4300   | 12000 |
| .....     | .....            | ..... | 11000  | 1200 | .....     | .....            | 4300  | 8200   | 10000 |
| .....     | .....            | ..... | .....  | 600  | .....     | .....            | 8200  | 11000  | 8000  |
| CM55      | .....            | ..... | 4300   | 2500 | .....     | .....            | 11000 | 24000  | 5000  |
| and       | .....            | ..... | 13000  | 1200 | .....     | .....            | 24000 | 68000  | 3000  |
| CM56      | .....            | 13000 | 33000  | 600  | .....     | .....            | 68000 | 100000 | 2000  |
| CM60      | .....            | ..... | 16000  | 2500 | CM90      | .....            | ..... | 1000   | 30000 |
| and       | .....            | ..... | 16000  | 1200 | .....     | .....            | 1000  | 1800   | 25000 |
| CM61      | .....            | 33000 | 47000  | 600  | .....     | .....            | 1800  | 3900   | 20000 |
| CM65*     | .....            | ..... | 2400   | 3000 | .....     | .....            | 3900  | 7500   | 15000 |
| .....     | .....            | ..... | 2400   | 2000 | .....     | .....            | 7500  | 9100   | 12000 |
| .....     | .....            | ..... | 7500   | 1500 | .....     | .....            | 9100  | 11000  | 10000 |
| .....     | .....            | ..... | 9100   | 1000 | .....     | .....            | 11000 | 16000  | 8000  |
| .....     | .....            | ..... | 24000  | 500  | .....     | .....            | 16000 | 30000  | 6000  |
| .....     | .....            | ..... | 43000  | 250  | .....     | .....            | 30000 | 62000  | 5000  |
| CM70*     | .....            | ..... | .....  | 5000 | .....     | .....            | 62000 | 75000  | 4000  |
| .....     | .....            | ..... | 2400   | 3000 | .....     | .....            | 75000 | 100000 | 3000  |
| .....     | .....            | ..... | 7500   | 2000 | CM95      | .....            | ..... | 1800   | 35000 |
| .....     | .....            | ..... | 22000  | 1500 | .....     | .....            | 1800  | 3300   | 30000 |
| .....     | .....            | ..... | 51000  | 1000 | .....     | .....            | 3300  | 5100   | 25000 |
| .....     | .....            | ..... | 75000  | 500  | .....     | .....            | 5100  | 6200   | 20000 |
| CM75      | .....            | ..... | 4700   | 6000 | .....     | .....            | 6200  | 10000  | 15000 |
| .....     | .....            | ..... | 4700   | 4000 | .....     | .....            | ..... | .....  | ..... |
| .....     | .....            | ..... | 11000  | 3000 | .....     | .....            | ..... | .....  | ..... |
| .....     | .....            | ..... | 16000  | 2000 | .....     | .....            | ..... | .....  | ..... |
| .....     | .....            | ..... | 27000  | 1500 | .....     | .....            | ..... | .....  | ..... |
| .....     | .....            | ..... | 68000  | 1000 | .....     | .....            | ..... | .....  | ..... |
| .....     | .....            | ..... | 80000  | 1000 | .....     | .....            | ..... | .....  | ..... |

\*Characteristic G in Case Sizes CM65 and CM70 are derated 50% in voltage and current ratings.

†Including.

# HIGHLIGHTS OF OLSON AND LEONARD PAPERS

Presented At N. Y. Meeting of Acoustical Society of America



Figures 1 (above) and 2 (right)

Figure 1, the force displacement characteristic of the suspension system of the cone of a direct radiator loudspeaker, discussed by Dr. Olson. Figure 2, theoretical undamped response frequency characteristic of a direct radiator loudspeaker with a nonlinear suspension system having a force displacement characteristic depicted in Figure 1.

*Action of a Direct Radiator Loudspeaker with Nonlinear Cone Suspension System. Harry F. Olson, RCA Laboratories, Princeton, New Jersey.*

**D**URING the past few years a number of mathematical investigators have directed their efforts toward the solution of differential equations with variable coefficients. These analyses, ex-

plained Dr. Olson, are useful in explaining some of the phenomena which occur in electroacoustic vibrating systems with nonlinear elements. In particular, this mathematics may be used to explain the various phenomena exhibited by a direct radiator loudspeaker with a nonlinear cone suspension system. One of the effects is a jump phenomenon in the response frequency characteristic. Another effect is the production of harmonics and subharmonics.

*Precision Method for Determination of Velocity of Sound in Air. R. W. Leonard, University of California, Los Angeles*

**A** METHOD has been developed and refined in the laboratory at UCLA for the measurement of the velocity of free progressive sound waves in air. The method involves wavelength measurements in a free sound field of known frequency. A directional source radiating spherical waves is placed at one end of the free field room. Measurements of positions of equal phase along the axis of the source are made with a movable microphone. The phase measurements are made on the screen of an oscilloscope. The amplified voltage developed by the microphone is applied to the vertical plates of the oscilloscope and a voltage derived from the source oscillator is applied to the horizontal plates. Closure of the ellipse on the oscilloscope screen is used to determine position of equal phase. The microphone is moved away from the

(Continued on page 88)

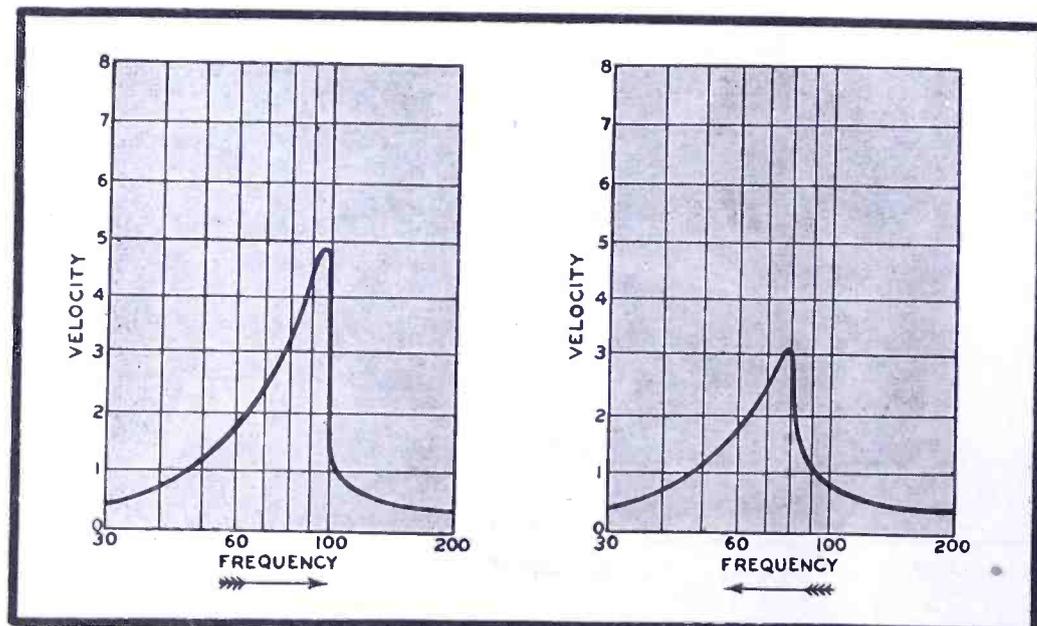


Figure 3

Experimental response frequency characteristics of a direct radiator loudspeaker with a non-linear suspension system having a force displacement characteristic shown in Figure 1. *A*: The response for an applied alternating voltage which continuously increases in frequency. *B*: The response for an applied alternating voltage which continuously decreases in frequency.



# COMMUNICATIONS TODAY AND TOMORROW

## As Viewed By Engineer-Executives

### A COMMUNICATIONS NAB Executives War Conference Feature

by **HOWARD S. FRAZIER**

Director of Engineering  
National Association of Broadcasters

AS this issue of COMMUNICATIONS goes to press, broadcasters are preparing for the NAB Executives War Conference in Chicago on August 28 to 31, and our industry approaches the fourth year of wartime operation. Those charged with responsibility for the technical operation of broadcast stations have, to a large extent, now established stable operating conditions. In other words, wartime operation has now become what we might call the normal practice instead of the new and untried. Problems of equipment maintenance and the training of replacement personnel have been met with little, if any, deterioration in service to the American public.

Broadcasting has always been an industry of growth, expansion and technical improvement. What is more natural then, at this time, than to turn our thoughts toward the future. The work of the *Radio Technical Planning Board* is well underway and already the panels on television and f-m have submitted reports which outline the technical standards recommended for these broadcast services in the post-war period. Panel 4 on *Standard Broadcasting* has completed work on many of the agenda items and a preliminary report from that group can be expected early in the fall of this year.

Aural broadcasting began soon after the first world war and continued to expand and develop rapidly through the years which preceded Pearl Harbor. Shortly after December 7, 1941, the plant expansion and development in this field, for the first time, came to almost a standstill. The industry devoted its efforts to rendering even greater service to the American public and to the winning of the war with the then existing facilities.

The time has now come to look forward into the future and to the resumption of the industry's plant ex-



Howard S. Frazier

pansion. Many of us feel very keenly the lack of the reliable crystal ball. We can be reasonably sure that many more aural broadcast stations will come on the air. But who *knows* what method of modulation these stations will use in 1950?

Will it be economically practical to provide local aural station service in communities of 5,000 to 10,000 people?

Will the problem of providing adequate rural coverage throughout the United States be solved?

Will the public buy television receivers in sufficient quantities to permit the rapid development of television service to small cities and national television networks?

Who will be the television broadcasters of the future? Will they be the present broadcasters, the movie interests, publishers or others who will

---

#### Technical Session NAB Executives War Conference

Thursday, August 31, Palmer House,  
Chicago

2:15 P.M.: Symposium on postwar future of broadcasting, Commander T. A. M. Craven presiding. Speakers will include Paul Chamberlain, G.E.; Niles Trammel, NBC; William Lodge, CBS; Thomas Joyce, RCA; Dr. E. H. Armstrong, who will cover f-m; Paul Godley, who will discuss a-m; and J. V. L. Hogan on facsimile.

---

dominate the new medium of mass communication?

I don't know the answers to these and many more questions heard frequently. But I do know the years ahead offer great opportunities, for service and achievement to those who are privileged to be part of radio.

by **O. B. HANSON**

Vice President and Chief Engineer  
National Broadcasting Co.

WAR, particularly modern war, gives an impetus to engineering progress that far exceeds normal developments in peace time. Yet, because of the single vital objective of this research and refinement—ultimate victory—little of the engineers' accomplishments can be reported for public consumption. When the war is brought to a successful finish or when national security permits, the communications industry will have a story to tell that will excite the imagination of those who have not been intimately concerned with laboratory and manufacturing activities.

In the broadcasting field the main problem has been maintenance. Yet with manufacturing facilities devoted almost entirely to the war effort it has not been possible to carry out many of the normal replacements for obsolete units that good engineering practice ordinarily dictates. This has made it necessary for stations to improvise numerous components and, in many instances, to construct replacements from available parts. That American broadcasters have been able to continue their high standard of service with few interruptions is a tribute to the ingenuity of engineering staffs.

Possibly the outstanding accomplishments in the past year have been the construction of the two short-wave station groups at Bound Brook, N. J., and Dixon, California. The six transmitters at Bound Brook were installed

(Continued on page 50)

ENGINEERING CONFERENCE

"WHY THAT'S JOCK!"



Right on the field of battle is the CBC truck with its Presto recorder taking down the sounds of battle, the words of Canadian men doing the fighting . . .

Yes! It actually happens. Canadian families are now hearing the voices of their own loved ones on the battlefronts, thanks to a program service originated by the Overseas News Service of CBC. This enterprising and much appreciated service consists of recordings made right on the scene of battle, the actual sounds of battle forming a terrible background. The recordings are rushed to Algiers, short-waved either via London or direct to Ottawa, where they are re-recorded, and sent out over the CBC leased lines. All this is made possible by the use of PRESTO Recording Equipment, which is used throughout the Canadian Broadcasting Corporation.



. . . Transmitted by short wave to BBC in London, the broadcast is re-recorded on one of the fifty complete Presto recording installations in the British Isles . . .



**Presto Recording Corporation, New York 19, N. Y., U. S. A.**

World's Largest Manufacturers of Instantaneous Sound Recording Equipment and Discs



. . . Short-waved again, this time to CBC in Ottawa, the battle-recorded broadcast is then sent over wire lines to the stations on the CBC networks across the Dominion.

# BROADCAST ANTENNAS AND ARRAYS

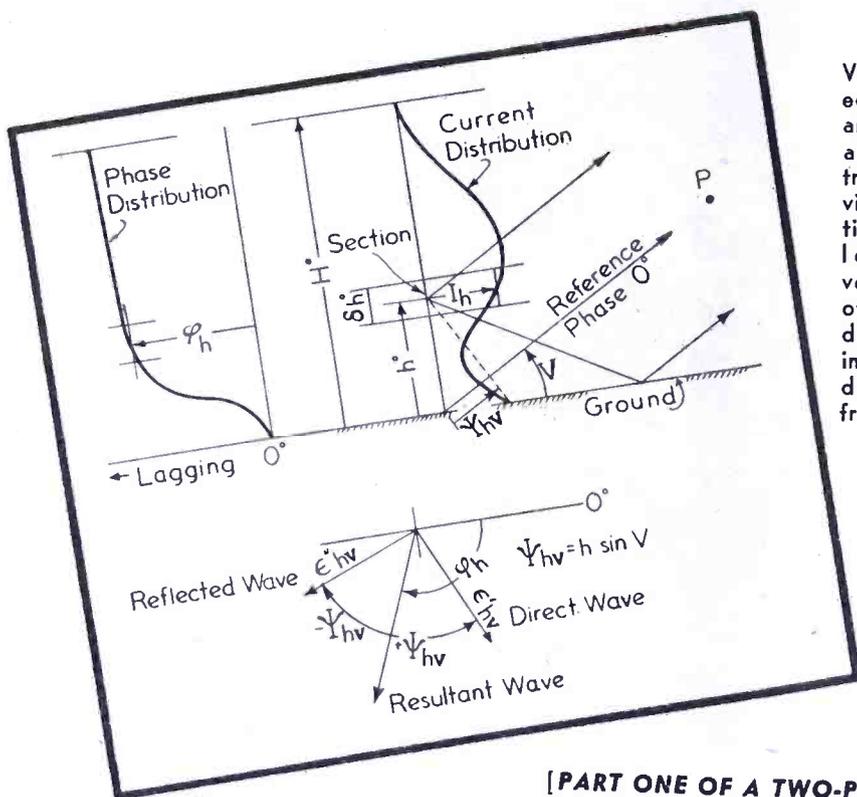


Figure 1  
Vertical ground antenna with arbitrary current and phase distribution, and divided into sections of equal length with vector diagram of fields at P due to current  $I_h$  in section  $h$ . All dimensions in free-space degrees.

[PART ONE OF A TWO-PART PAPER]

THE non-sinusoidal current distribution in practical broadcast antennas yields patterns that differ from the ideal usually assumed. The discrepancy is more pronounced in the case of arrays than in single antennas. The computation method

outlined in this paper is independent of current distribution and phase-shift along the antenna.

Methods for measuring relative current and phase in antenna systems have been described.<sup>1,2,3,4</sup> It is therefore assumed that the relative current

Table 1

Values for the function  $f(h, V) = \cos(h \sin V) \cos V$ ; (for slide rule use)

| h<br>Degrees | Values of the function: $\cos(h \sin V) \cos V$ |         |         |         |         |         |         |         |
|--------------|---|---------|---------|---------|---------|---------|---------|---------|
|              | V = 10°   | V = 20° | V = 30° | V = 40° | V = 50° | V = 60° | V = 70° | V = 80° |
| 5.....       | 0.985   | 0.940   | 0.865   | 0.764   | 0.642   | 0.499   | 0.342   | 0.173   |
| 15.....      | 0.984   | 0.936   | 0.858   | 0.756   | 0.630   | 0.487   | 0.332   | 0.168   |
| 25.....      | 0.982   | 0.930   | 0.845   | 0.736   | 0.608   | 0.465   | 0.314   | 0.158   |
| 35.....      | 0.979   | 0.919   | 0.826   | 0.708   | 0.574   | 0.432   | 0.287   | 0.143   |
| 45.....      | 0.976   | 0.906   | 0.800   | 0.670   | 0.530   | 0.389   | 0.253   | 0.124   |
| 55.....      | 0.971   | 0.890   | 0.768   | 0.624   | 0.477   | 0.337   | 0.212   | 0.102   |
| 65.....      | 0.966   | 0.872   | 0.730   | 0.571   | 0.418   | 0.278   | 0.165   | 0.076   |
| 75.....      | 0.959   | 0.847   | 0.687   | 0.511   | 0.347   | 0.212   | 0.114   | 0.048   |
| 85.....      | 0.952   | 0.822   | 0.638   | 0.444   | 0.271   | 0.144   | 0.061   | 0.019   |
| 95.....      | 0.944   | 0.793   | 0.585   | 0.371   | 0.190   | 0.067   | 0.004   | -0.011  |
| 105.....     | 0.936   | 0.761   | 0.527   | 0.293   | 0.107   | -0.009  | -0.051  | -0.040  |
| 115.....     | 0.926   | 0.726   | 0.465   | 0.212   | 0.022   | -0.084  | -0.106  | -0.068  |
| 125.....     | 0.915   | 0.691   | 0.400   | 0.128   | -0.063  | -0.156  | -0.157  | -0.095  |
| 135.....     | 0.903   | 0.651   | 0.332   | 0.043   | -0.147  | -0.227  | -0.205  | -0.118  |
| 145.....     | 0.891   | 0.609   | 0.261   | -0.041  | -0.230  | -0.291  | -0.246  | -0.138  |
| 155.....     | 0.878   | 0.566   | 0.187   | -0.128  | -0.310  | -0.347  | -0.282  | -0.154  |
| 165.....     | 0.865   | 0.520   | 0.113   | -0.211  | -0.380  | -0.399  | -0.310  | -0.166  |
| 175.....     | 0.850   | 0.472   | 0.038   | -0.294  | -0.447  | -0.440  | -0.330  | -0.172  |
| 185.....     | 0.836   | 0.423   | -0.038  | -0.371  | -0.505  | -0.471  | -0.340  | -0.174  |
| 195.....     | 0.818   | 0.373   | -0.113  | -0.443  | -0.553  | -0.491  | -0.342  | -0.170  |
| 205.....     | 0.801   | 0.320   | -0.187  | -0.511  | -0.592  | -0.499  | -0.334  | -0.161  |
| 215.....     | 0.783   | 0.270   | -0.261  | -0.570  | -0.620  | -0.497  | -0.317  | -0.147  |
| 225.....     | 0.765   | 0.211   | -0.332  | -0.625  | -0.637  | -0.483  | -0.292  | -0.128  |

## Calculation of Radiation Patterns

by WILSON PRITCHETT

Radio Engineer  
E. F. Johnson Company

and phase distribution on each antenna is known or can be measured. Since practical broadcast antennas usually employ extensive ground systems that approach the ideal,<sup>1</sup> a perfect earth has been assumed in computing the patterns.

### Absolute and Relative Patterns of Single Antennas

Let us consider the antenna of Figure 1, with its current and phase distribution as shown. The vector diagram gives the magnitude and phase at the remote point, P, of the direct and reflected increments of the field produced by the current,  $I_h$ , flowing in a section. The resultant is

$$\epsilon_{hv} | \phi_h = 2 \left[ \frac{60\pi \delta_h}{d \cdot 360^\circ} I_h | \phi_h (\cos(h \sin V) \cos V) \right] \text{ volts per unit } d \quad (1)$$

For the section,  $\delta_h$ , 10° long and the distance, d, to point, P, 1 mile,

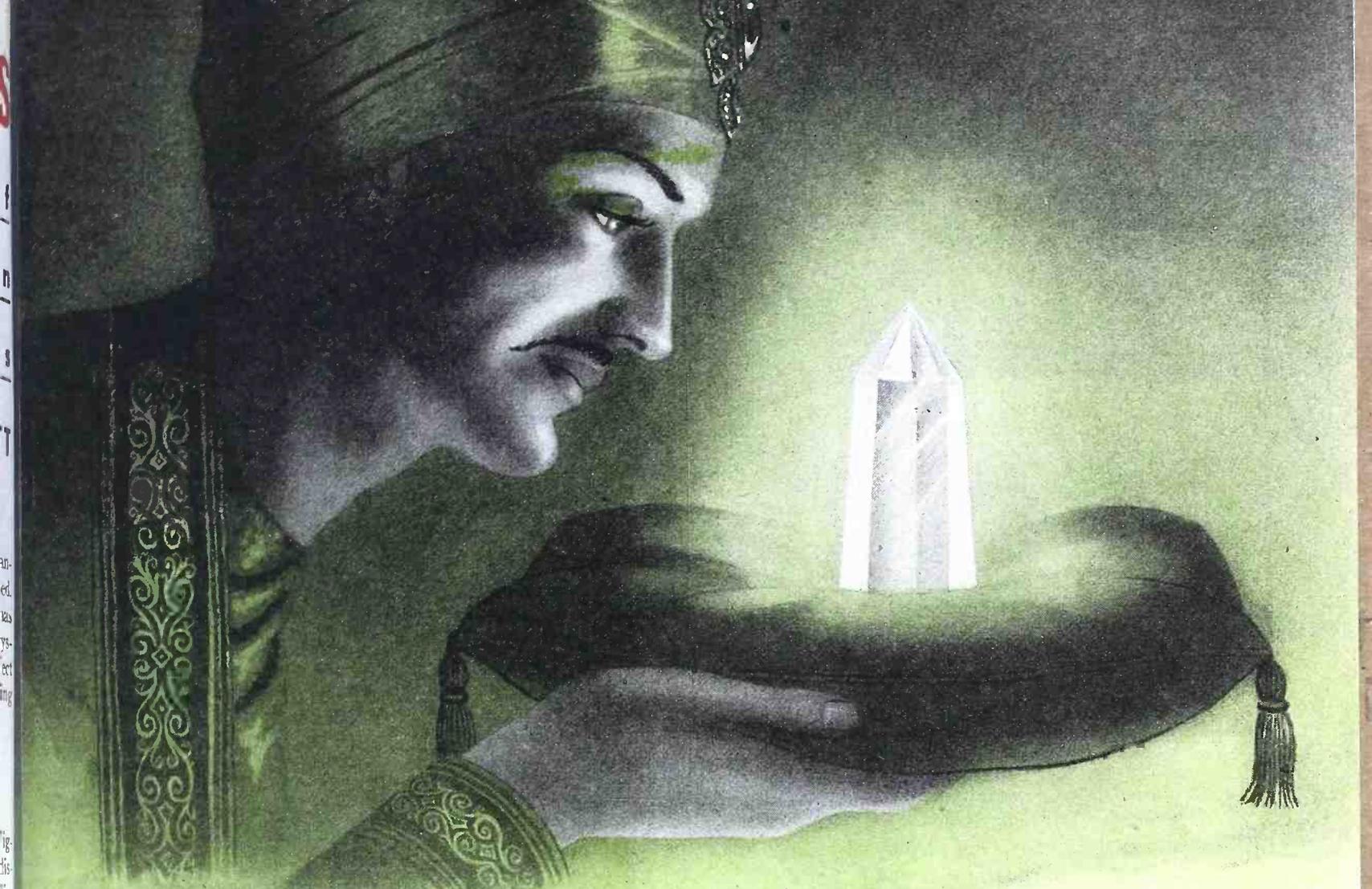
$$\epsilon_{hv} | \phi_h = 0.00651 I_h | \phi_h f(h, V) \text{ volts per meter} \quad (2)$$

Certain values of the function  $f(h, V)$ , useful in the study of broadcast antennas, are given in Table 1.

Finally it is necessary to combine the contributions from all sections vectorially to find the total resultant field ( $\epsilon_v | \phi_v$ ) at point, P, for a given elevation angle V.

$$\epsilon_v | \phi_v = \sum_{h=H^\circ}^{\delta h^\circ} \frac{\epsilon_{hv} | \phi_h}{2} \text{ volts per unit } d \quad (3)$$

Determination of patterns for arrays requires, first the determination of the individual relative patterns. All antennas are divided into equal sections,  $\delta_h$ , and the relative current and phase distribution expressed with respect to unity current ratio and zero



# War Gem Today

WHAT WILL THE QUARTZ CRYSTAL DO TOMORROW?

The fabled princes of Hindustan or the wealthy Nizam of Hyderabad never owned a gem more valuable.

The quartz crystal is doing more than rubies or emeralds to protect our way of life against the aggressor.

Cut into tiny wafers the quartz crystal is performing with merit wherever fixed radio frequencies are a "must".

Federal is mass producing frequency control crystals for military use. How many difficult jobs they are doing is a war secret. But their versatility is unlimited.

Even now—in the great FTR research laboratories—men are finding new uses for

quartz crystals—pointing the way to widespread industrial and civilian use after the war is won.

Not alone in communications—but in such widespread applications as precision timing and measuring devices, television, supersonics, pressure gauges, filters, generators, induction heating devices and automatic control equipment, crystals will find new uses . . . a war gem will become a peacetime servant.



*Megatherm, Federal's pioneering induction and dielectric heating equipment, is giving outstanding production line performance in the metals, plastics, food, textile and other industries.*

To achieve mass production Federal has installed new machinery and new methods to speed crystals on their way to war—and will continue to be a leader in crystal production. Now is the time to get to know Federal.

**Federal Telephone and Radio Corporation**



Newark 1, N. J.

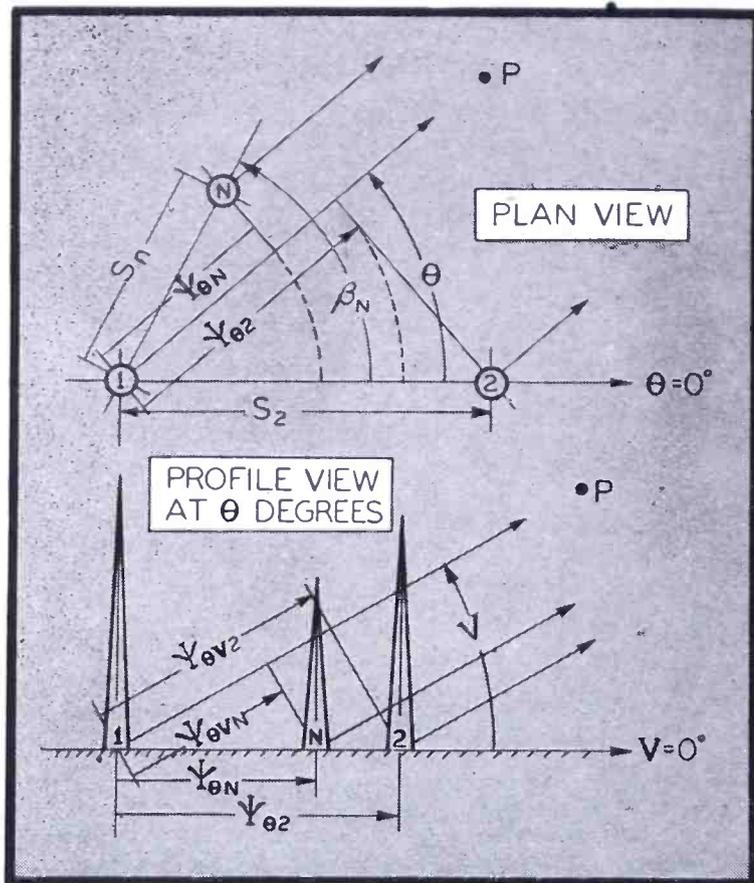


Figure 2  
Plan and profile view  
of multi-element  
array of vertical  
antennas.

tennas. It is merely necessary to combine them vectorially at the proper angles accounting for the differences in path length traveled,  $\Psi_{\theta V N}$ , and the actual time phase,  $\phi_{V N}$ , of the individual fields. Thus, the resultant relative field intensity from the array is

$$K_{\theta V} = k_{v1} |\phi_{v1} + k_{v2} |\phi_{v2} + \Psi_{\theta V 2} + \dots + k_{vN} |\phi_{vN} + \Psi_{\theta V N} \quad (6)$$

From Figure 2 it is easily seen that  $\Psi_{\theta V N} = S_N \cos(\theta - \beta_N) \cos V$  (7)

The vector addition represented by equation 6 is a special feature of various antenna pattern calculators that have been described.<sup>6,7,8</sup>

The protractor reproduced in Figure 3, mounted on a sheet of stiff cardboard and fitted with a transparent radial index arm, can be used advantageously in laying off the angles  $(\phi_{V N} + \Psi_{\theta V N})$ .

#### Protractor Description and Use Procedure

The circular arcs numbered from 30° to 330° indicate  $\Psi_{V N}$  which is constant for any vertical angle  $V$  and equal to  $S_N \cos V$ . A table of values for  $\Psi_{V N}$  is computed for the various elevation angles  $V$ . The angle  $\Psi_{\theta V N}$  is read directly from the intersections of the spiral lines with the  $\Psi_{V N}$  arc for the specific elevation angle  $V$ . The spirals are drawn for 10° increments of  $(\theta - \beta_N)$ , and so use of the protractor is limited to  $\beta_N$  taken at 10° intervals. Interpolation for intermediate values of  $\Psi_{V N}$  is easy, however. Figure 4 shows the vector diagram for a specific elevation angle,  $V$ , of a simple array. Advantage is taken of the fact that  $k_{vN}$ ,  $\phi_{vN}$  and  $\Psi_{V N}$  are constant. The relative field from the reference antenna  $k_{v1}$  is laid off at the angle  $\phi_{v1}$ . Upon its ends are laid off arcs with radii  $k_{v2}$  and  $k_{v3}$ , as shown. Upon these arcs are laid off values of  $\Psi_{\theta V N}$ , with the aid of the protractor of Figure 3 mounted as described, and having a hole at the origin for centering it upon the ends of the vector  $(k_{v1} |\phi_{v1})$ . First the phase angle  $\phi_{vN}$  is laid off as shown and the zero on the rim of the protractor laid in that direction. Successive angles  $\Psi_{\theta V N}$  are then laid off from  $(\theta - \beta_N) = 0^\circ$  to  $(\theta - \beta_N) = 90^\circ$ . These two extremities are  $\Psi_{V N}$ , and zero, read from the rim of the protractor. Intermediate values of  $\Psi_{\theta V N}$  are plotted from successive intersections of the spirals with the arc  $\Psi_{V N}$ . A pair of dividers can be used to lay off these same intervals on the other side of  $\phi_{vN}$  for  $(\theta - \beta_N)$  continuing from 90° to 180°. Returning on the same points gives suc-

phase at the base of one antenna taken as a reference. Mutual impedance between antennas destroys the quantitative relationship of equation 1, and the individual relative patterns must be found first. This is done by re-writing equation 2, using relative current,  $k_b |\phi_b$ , in each section,  $\delta_h$ , to compute the relative increment of field,  $k_{hv} |\phi_h$ . The constant term is dropped.

$$k_{bv} |\phi_h = k_h |\phi_h f(h, V) \quad (4)$$

The total relative field,  $k_v |\phi_v$ , is the vector sum of the contributions from the sections, and corresponds to equation 3:

$$k_v |\phi_v = \sum_{h=0}^{\delta_h} \frac{k_{hv} |\phi_h}{2} \quad (5)$$

The procedure for using Table 1 and equation 2 or 4, to find the pattern of an antenna, is:

- (1)—Prepare a table of the form of Table 1, inserting columns for  $0.00651 I_h$  (or  $k_h$ ) and  $\phi_h$ , in which the other tabulations consist of products of  $0.00651 I_h$  (or  $k_h$ ), and the corresponding value of  $f(h, V)$  from Table 1.
- (2)—With the aid of an engineer's scale and protractor (or drafting machine) we add vectorially each column. Since all values in each horizontal row are laid off at the same angle ( $\phi_h$ ), it is expedient to use a drafting machine and prepare a single

vector diagram for the entire table. After all vectors are drawn, the magnitude and phase of the field at each elevation angle is measured and tabulated at the end of the proper column.

In the case of short antennas, in which the phase distribution is constant, the columns are simply added algebraically.

Tall antennas have a number of the functions,  $f(h, V)$ , negative, and it is usually necessary to provide a fairly large sheet of detail paper to avoid passing off the edge.

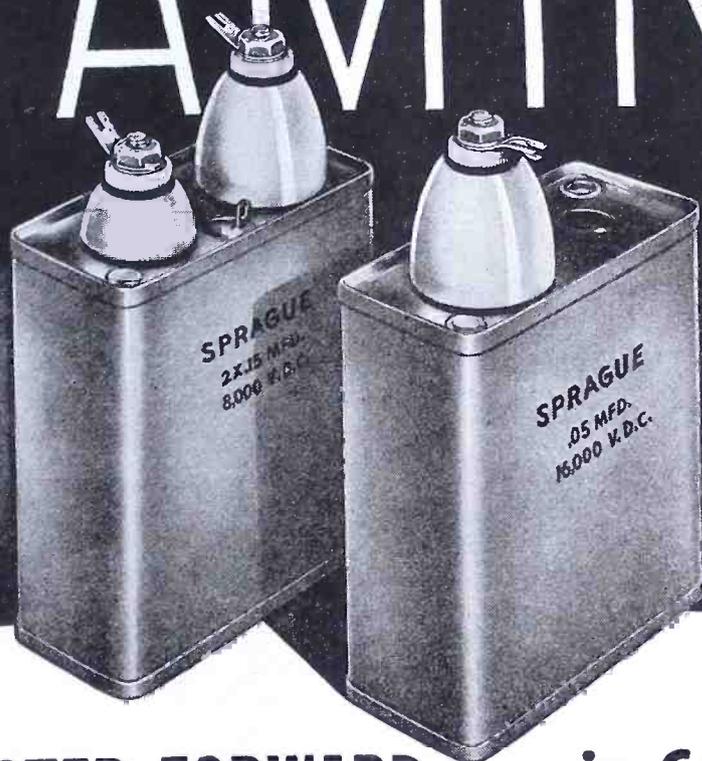
The writer has found application of the 10° schedule of Table 1 to ideal antennas up to 220° tall, to give results that check the well known formulas within a fraction of a per cent.<sup>9</sup>

#### Relative Patterns of Arrays

Figure 2 shows the plan view and one profile view of a multi-element array. The reference horizontal direction,  $\theta = 0^\circ$ , is in a vertical plane passing through the reference antenna 1, and any other antenna 2, spaced  $S_2$  degrees from antenna 1, and is directed from the reference antenna 1 to the other antenna 2. The other antennas lie in arbitrary directions,  $\beta_N$ , at arbitrary spacings  $S_N$ .

Since the relative phase and magnitude of the individual fields have been determined with respect to the relative phase and magnitude of the base currents, and the earth assumed perfect, the fields at point  $P$ , due to the individual antennas, appear to emanate from the bases of the an-

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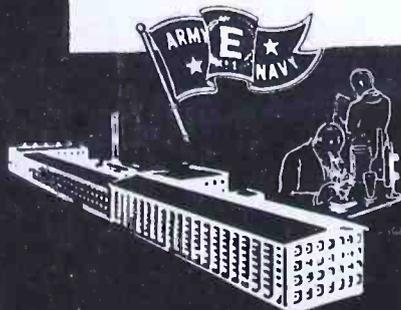
itors retain all of the virtues of conventional oil-impregnated capacitors throughout the extreme range of +105° C. to -40° C. Used where high temperature is not a factor, they result in materially higher ratings for a given size.

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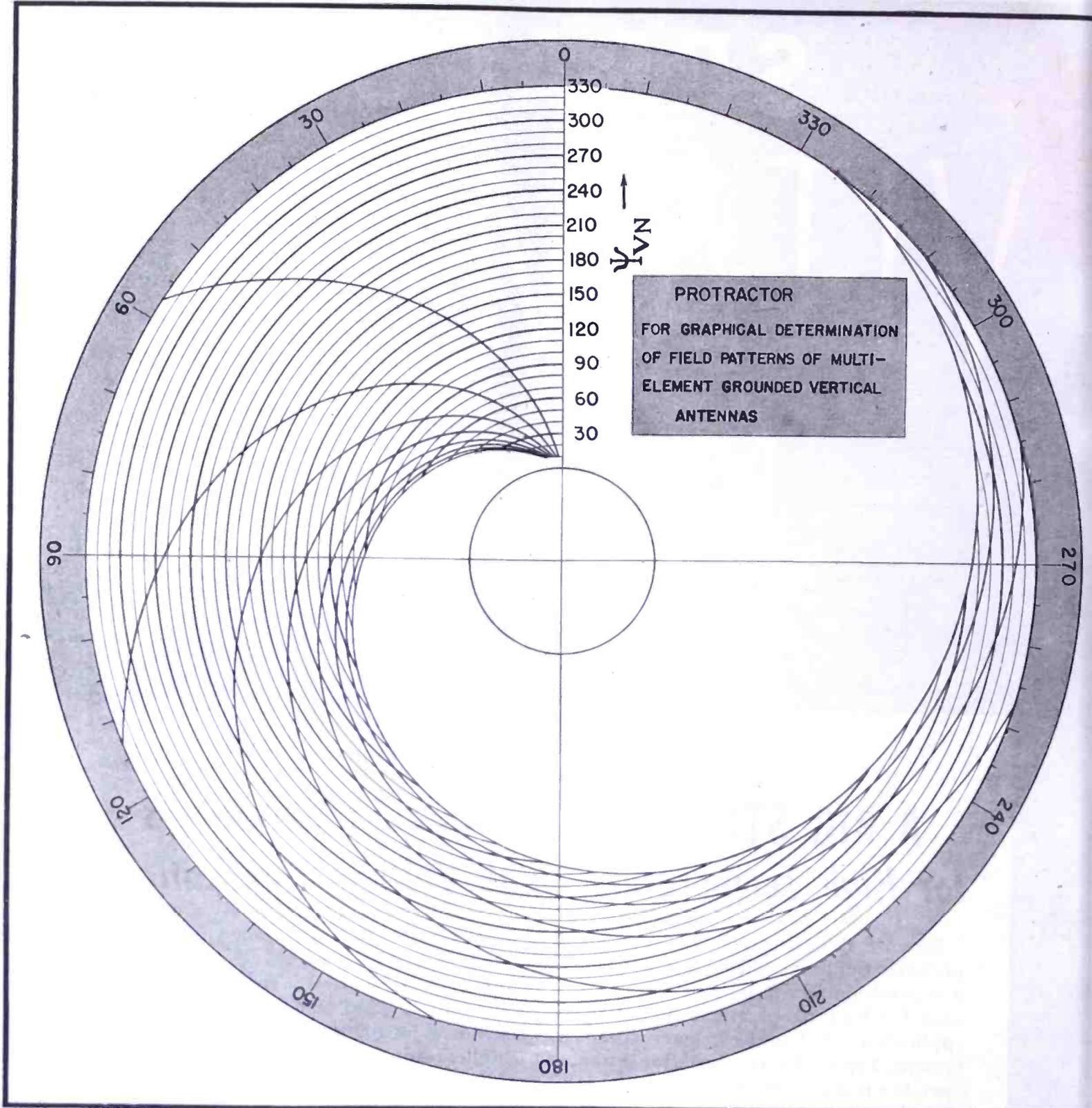


Figure 3

Protractor for mounting on cardboard and fitting with a transparent ruled radial arm. A hole is provided in center bearing for observing centering of protractor on vector diagram.

cessive values of  $\Psi_{\theta VN}$  from  $180^\circ$  to  $360^\circ$ .

In the case of arrays of more than three antennas, it is necessary to lay off the proper values of  $(\phi_{VN} + \Psi_{\theta VN})$  upon the end of a moving vector. The dividers are used to measure the total resultant relative field,  $K_{\theta V}$ , which is the displacement between the ends of the corresponding vectors. The displacements are plotted directly on polar coordinates as measured. Use was made of the proportional dividers set at 0.5 to 1.0, Figure 4.

#### Adjustment of Relative Patterns

The total power,  $P$ , radiated from

an antenna system is the summation of the power flowing out through the zones of an enclosing hemisphere and is

$$P = 2\pi d^2 \delta_v (0.00265) \sum_{z=1}^{z=N} \epsilon_z^2 \cos V_z \quad (8)$$

watts

where:

$d$  = the radius of the hemisphere in meters

$N$  = the number of zones, all having equal central angles into which the surface of the hemisphere is divided

$$\delta_v = \frac{\pi}{2N}$$

$V_z$  = elevation angle to the center of the zone

$\epsilon_z$  = the effective field in volts per meter

in the zone. Its value is quite accurately

$$\epsilon_z^2 = \frac{\epsilon_L^2 + \epsilon_U^2}{2}$$

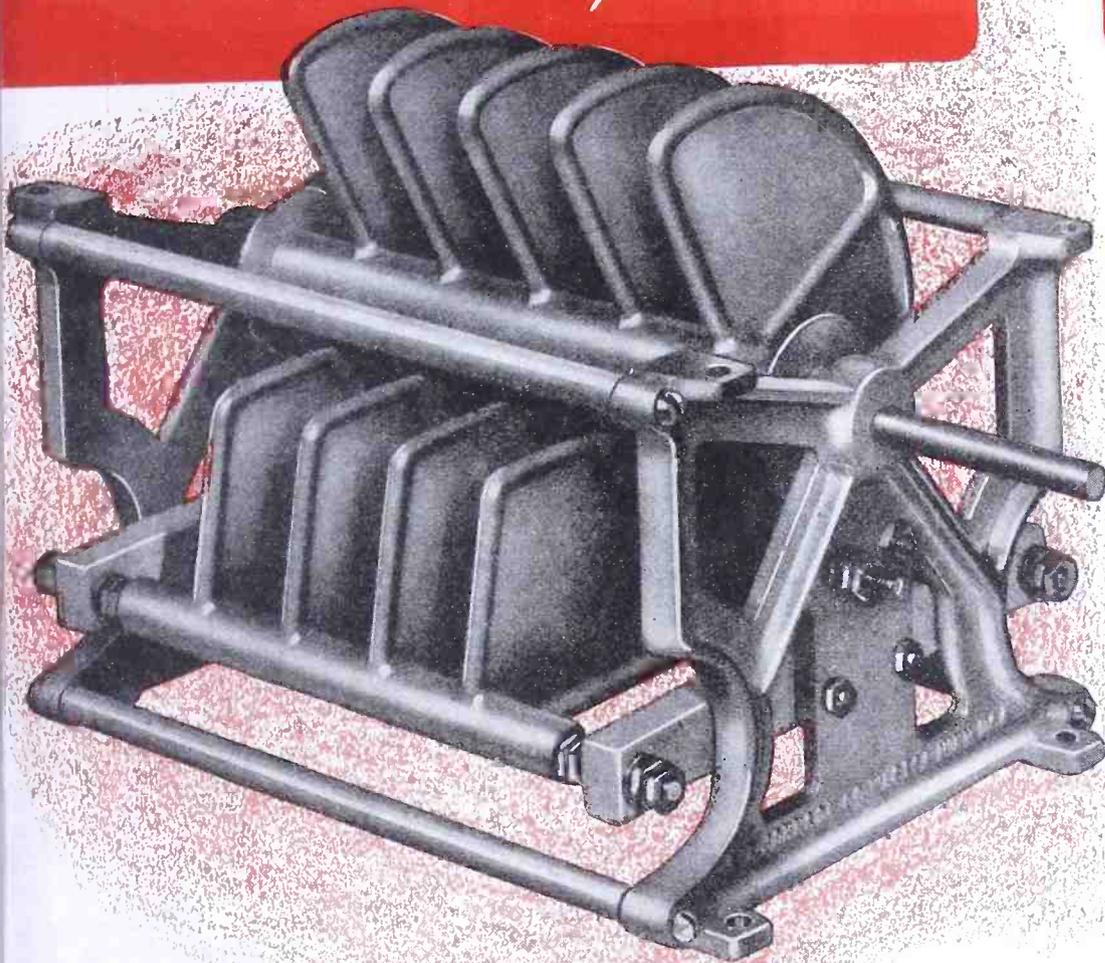
where  $\epsilon_L$  is the effective field at the lower edge of the zone, and  $\epsilon_U$  is the effective field at the upper edge of the zone. The effective field at the edge of a zone is equal to the radius of a circle having the same area as a polar plot of the actual field around the edge of the zone.

For the hemisphere with a mile radius and divided into  $10^\circ$  zones, the square-root of the summation in equation 8 becomes

$$\sqrt{\sum_{z=1}^{z=9} \epsilon_z^2 \cos V_z} = 0.3645$$

for 1000 watts radiated (9)

# New Development



Again Johnson scores a first with newly designed thick plates which allow much higher voltages, particularly at high frequencies.

It has long been known that plates with rounded edges have higher breakdown voltages in variable condensers, but it remained for Johnson Engineers to work out ratios of plate thickness, design, voltage, and spacing for maximum advantage.

Greatly decreased length (as much as one-third in some cases) results in lower minimum capacity and lower inductance due to shorter frame rods and other metal parts, which is extremely important at high frequencies.

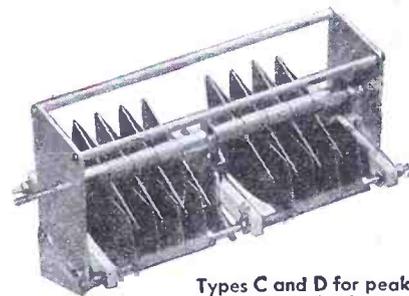
Corona is noticeably less with the new type plates and corona shields have been added where stator bars enter insulators, resulting in still further improved performance.

Despite these many improvements, in most cases prices are lower because of the saving in material.

Now available in Types A and B, both fixed and variable, this new plate shape and construction will be incorporated in other types as quickly as possible. Write Johnson today for more information and for recommendations on YOUR variable condenser application.

New Catalog 968E now ready.

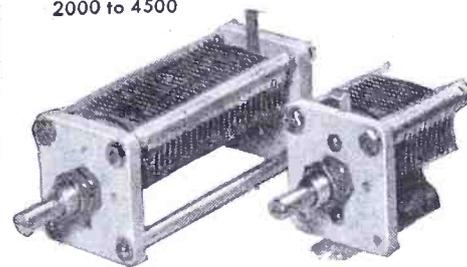
Decreased Spacing  
Shorter Length  
Lower Minimum  
Less Inductance



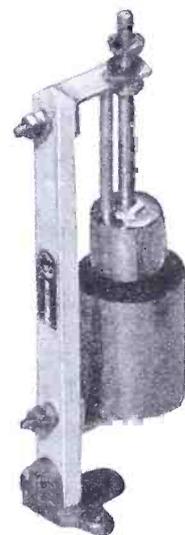
Types C and D for peak voltages of 3500 to 13,000



Types E and F for peak voltages of 2000 to 4500



Type H for peak voltages of 1500 to 3000



Type N neutralizing condensers in 5 sizes

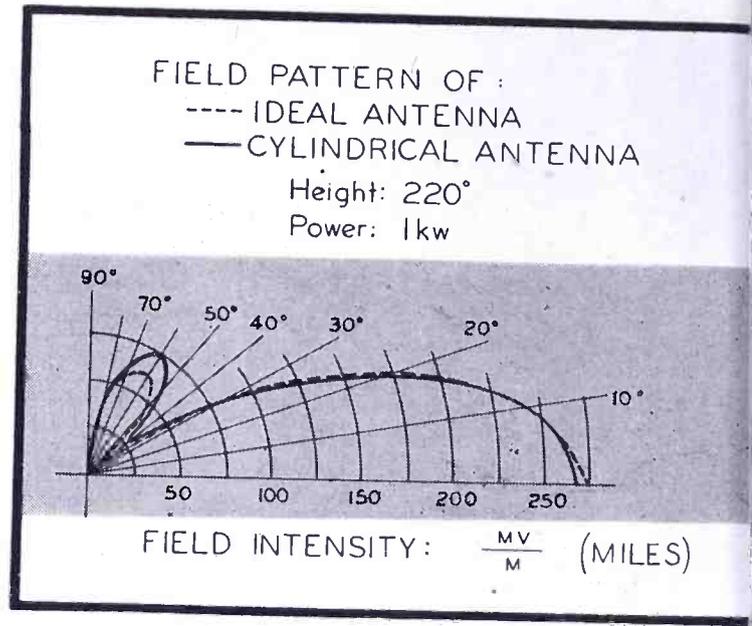
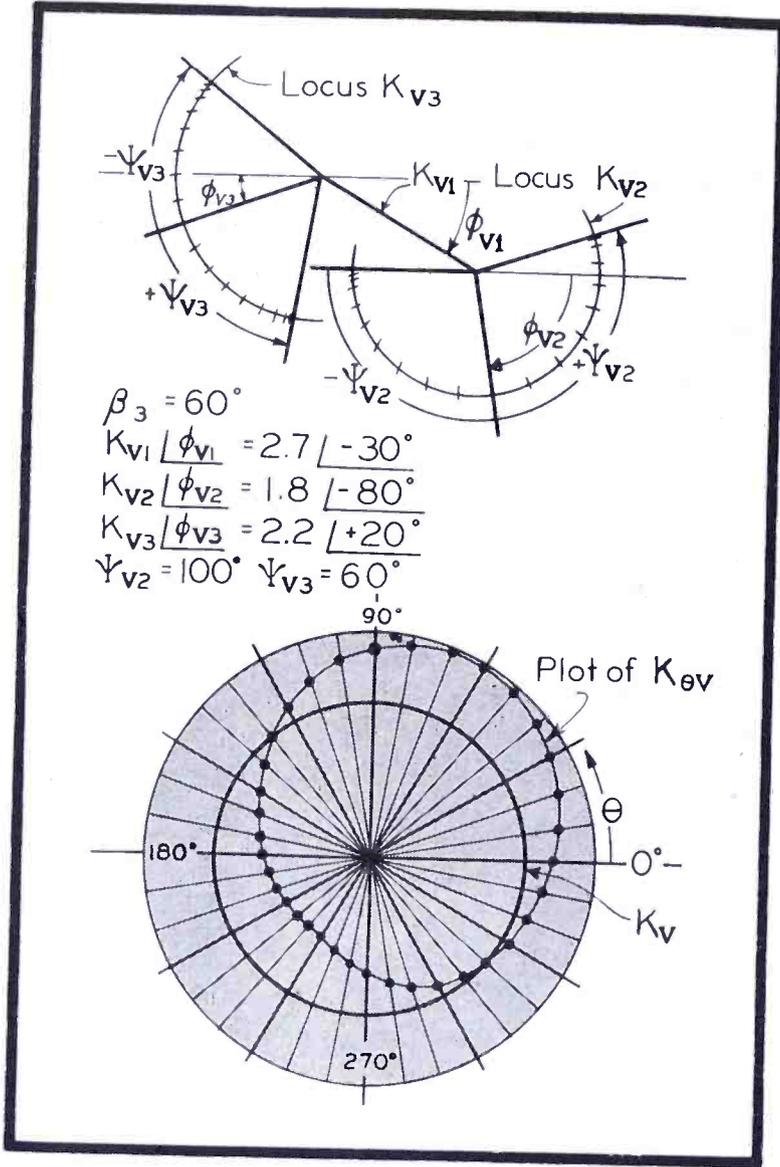


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Figures 4 (left), 5 (above), and 6 (below)  
 In Figure 4 we have a vector diagram of individual relative fields of a 3-element array drawn with the aid of protractor shown in Figure 3. The resulting pattern ( $K_v$ ) and its rms value ( $K_v$ ) is shown. Figure 5 shows a comparison of fields from ideal and practical antennas. Figure 6, a comparison of fields in the line of towers of ideal and practical 2-element arrays having horizontal patterns of identical shape.

If we consider the relative pattern of an array resulting from the summation of equation 6, and let the actual field intensity for one kilowatt radiated be related to the relative field by the factor  $M$ , we find that

$$\epsilon_{\theta v} = M K_{\theta v} \quad \text{volts per meter at a mile} \quad (10)$$

Let  $K_z$  be the relative effective field in a zone corresponding to  $\epsilon_z$  for the effective field in volts per meter in the zone, and

$$M = \frac{0.3645}{\sqrt{\sum_{z=1}^9 K_z^2 \cos V_z}} \quad (11)$$

A simple procedure for evaluating  $M$  is:

- (1)—Tabulate  $V$  and  $V_z$ ,  $5^\circ$  increments
- (2)—Tabulate  $K_v$  and  $K_v^2$  opposite the proper even  $10^\circ$  increments of  $V$ . (See Figure 4 for  $K_v$ )
- (3)—Average successive values of  $K_v^2$  and tabulate  $K_z^2 = \frac{K_L^2 + K_U^2}{2}$  opposite the alternate  $10^\circ$  increments,  $V_z$  ( $5^\circ, 15^\circ$ , etc.)
- (4)—Multiply each  $K_z^2$  by its  $\cos V_z$
- (5)—Divide 0.3645 by the square root of the total of the column ( $K_z^2 \cos V_z$ )

Now that  $M$  is found, equation 10 adjusts the relative pattern to the absolute field intensity in volts per

meter at a mile for one kilowatt radiated. The field intensity for any other value of power is equation 10 multiplied by the square-root of the actual power in kilowatts.

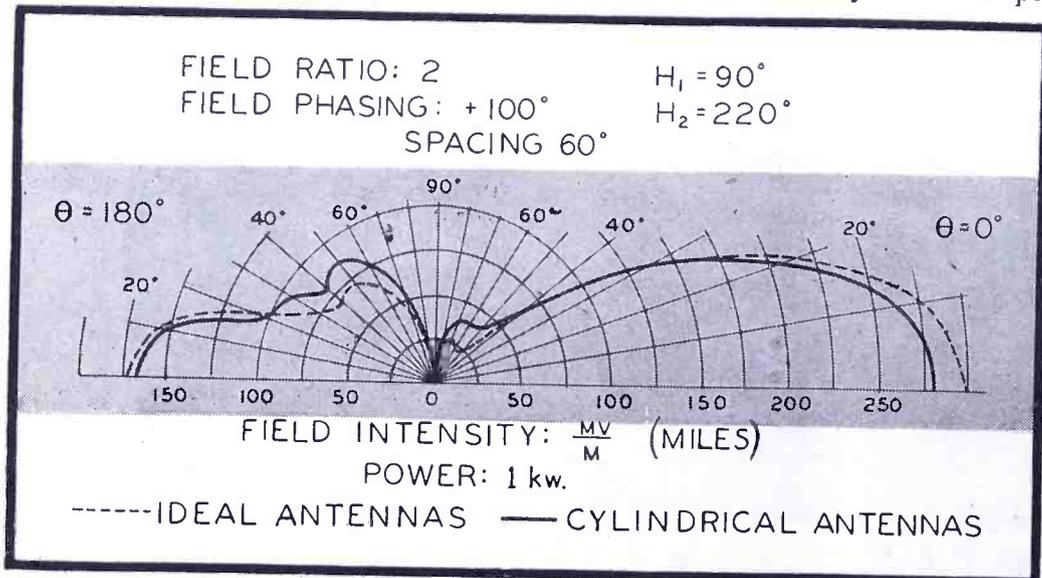
**Ideal and Actual Patterns**

Figure 5 shows the comparison of the vertical directivity of an ideal  $220^\circ$  antenna with one in which the current and phase distribution more nearly approach that to be found in actual uniform cross-section antennas. The current and phase distribution used were adapted from a recent paper.<sup>9</sup>

Figure 6 shows a similar comparison for a two-element array in which the sections shown are in the line of towers. The relative magnitude and phase of the base currents for the two cases were adjusted so that the shapes of the two horizontal patterns were identical. It is seen that the difference is greater in the case of arrays than in the case of a single antenna.

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- <sup>2</sup>Morrison and Smith, *The Shunt Excited Antenna*, Proc. IRE; June 1937.
- <sup>3</sup>J. E. Morrison, *Simple Method for Observing Current Amplitude and Phase Relations in Antenna Arrays*, Proc. IRE; October 1937.
- <sup>4</sup>Brown and Swift, *Phase Meter of Many Uses*, Broadcast News; July 1938.
- <sup>5</sup>Terman, F. E., *Radio Engineer's Handbook*, McGraw Hill Book Co., pp. 792-4; 1943.
- <sup>6</sup>Everest and Pritchett, *Horizontal-Polar-Pattern Tracer for Directional Broadcast Antennas*, Proc. IRE; May 1942.
- <sup>7</sup>Hutton and Pierce, *A Mechanical Calculator for Directional Antenna Patterns*, Proc. IRE; May 1942.
- <sup>8</sup>C. E. Smith and E. L. Gove, *An Electromechanical Calculator for Directional Antenna Patterns*, Trans. AIEE, pp. 79-83; February 1943.
- <sup>9</sup>King and Harrison, *Distribution of Current along a Symmetrical Center-Driven Antenna*, Proc. IRE, Figure 17; October 1943.



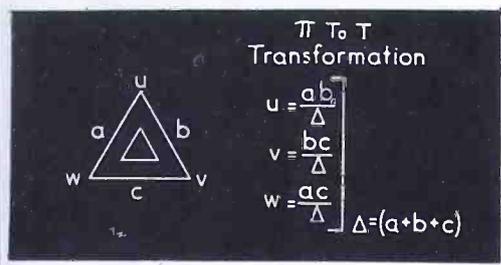


Figure 2, above  
A convenient form for making the transformation from a given  $\pi$  network to an equivalent T type.

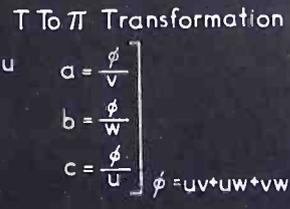
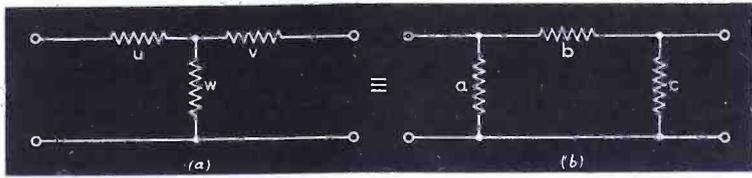


Figure 3, above  
A convenient form for transforming from a given T to a  $\pi$  network.

# RESISTIVE ATTENUATOR, PAD AND NETWORK Theory and Design

by PAUL B. WRIGHT  
Communications Research Engineer

The basic theory of resistance network transformations is presented in this initial installment, together with completely tabulated functions of a real variable which form the foundation from which the whole structure of all of the standard forms of purely resistive networks may be built.

ber of primes or subscripts. However, Greek symbolic notation will be used throughout the paper in accordance with standards of past mathematical and good engineering practices to provide unity of form and compactness of expression. No attempt will be made to prove the various theorems used, but references to textbooks and papers where they may be found will appear at the conclusion of the paper.

This series will offer in compact form the major portion of the theory and design of resistive attenuating networks. Tabulated functions of a real variable over the range of attenuation from 0.01 to 150.0 db will be presented. The headings of the tables will give the relationship existing between the algebraic, exponential, hyperbolic and the symbolic functions used in this paper. Since they will all be functions of a real variable, they can also be used successfully whenever dealing with mathematical notations having the same form. This form of presentation gives a concise and accurate means of showing the transformations from algebraic to hyperbolic forms as well as the exponential and symbolic notations. The tables presented with each part of the paper will be complete. They will be extensive enough to allow the design of any of the standard forms of attenuating networks. The tables will also facilitate obtaining the constants for other forms of networks which do not come under the standard classifications ordinarily used.

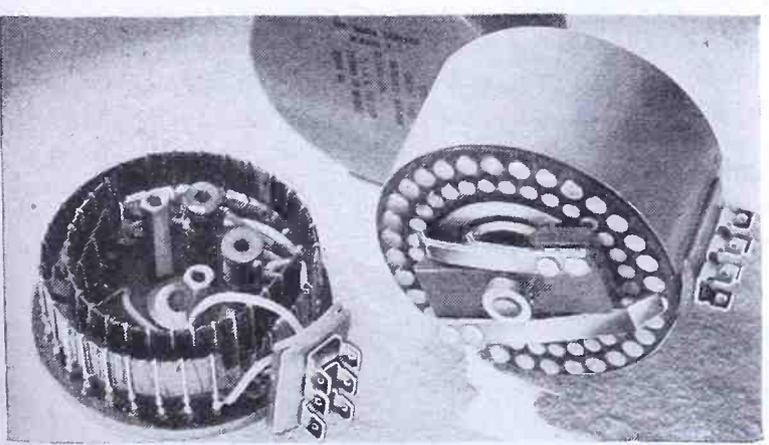
mitted. After the classic paper of McElroy in 1935, practically all notations were changed to conform to the nomenclature used in that paper wherever possible, since the writer believes that standardization in symbolical notation for networks of standard or common configurations should be used whenever it is convenient to do so. This policy has been adopted for this paper. Other notations of the author have been for the sake of completeness and clearness wherever no precedence in symbols has been set or whenever translation of existing theory into the conforming symbolic notation of this paper has been found necessary.

IN the design of attenuating networks, the factors of most usual interest are those of insertion loss and the impedances between which the network must be placed to give the loss required. The insertion loss is defined as ten times the logarithm, to the base 10, of the ratio of the power delivered to a given load before insertion of a network to that delivered after its insertion. Since considerable simplification of the theory, as well as the practice of network design and operation is obtained if the network is assumed to be properly matched on an image basis, this is the usual assumption made in the design of standard attenuating networks or pads as they are commonly called. On the image

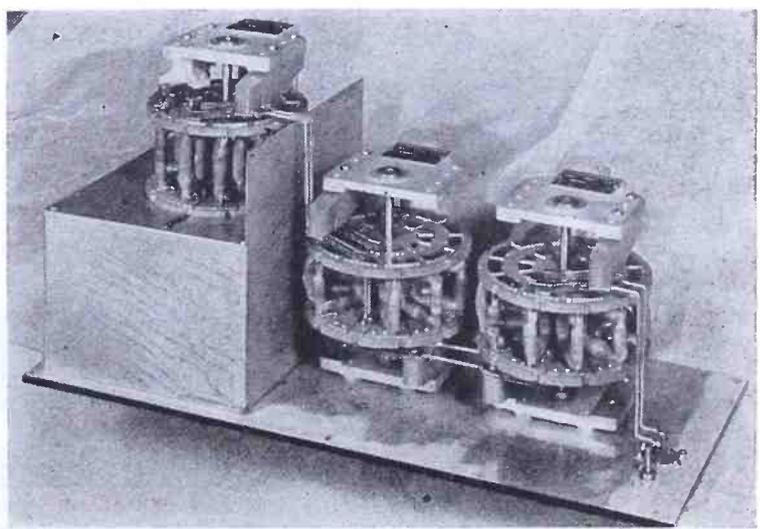
In this paper will appear a portion of the notes, data and calculations initiated by the author in 1932. Revisions and rearrangements of material have been made as time and engineering experience per-

Whenever and wherever compression of mathematical equations were usable without sacrificing clarity of detail or purpose, suitable symbols have been used. Another important simplification applied in the treatment of pure resistance types of networks encompasses the use of English characters with a minimum num-

(Continued on page 52)



Above, a bridged T attenuator, with and without case. (Courtesy Daven). At right, a 100-ohm balanced shielded attenuator. (Courtesy Leeds and Northrup).



**THE LATEST, UP-TO-THE-MINUTE RADIO AND ELECTRONIC CATALOG IN THE COUNTRY TODAY!**

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*(Continued from page 40)*

by NBC and are being operated by NBC under special arrangement with the OWI. A similar set-up at Dixon is under construction on the same basis and should be in operation within a few months.

These short-wave transmitters are of the most modern design. They feed an array of twenty or more antennas so oriented as to make programs available to all European countries, Latin America and South America. The California transmitters will provide programs for the Antipodes, the Orient and the USSR.

Television and f-m, as the public now realizes, are certain to be two of the most active postwar radio services. But here too, military priorities have held civilian development in close check. Limited program experimentation has been carried out, but receivers have not been manufactured since early in 1942. However, it is known that manufacturers are making plans for the resumption of set production in both f-m and television as soon as facilities can be converted from war to peace time production.

**by J. R. POPPELE**

Chief Engineer, WOR

**T**HAT the war has not hindered the progress of the communications art to as great an extent as is generally thought by the layman is affirmed by the great strides taken in the production of complex Army and Navy communications matériel. Especially during the last year the public eye has been trained upon the progress in direction equipment, the use of f-m broadcasting in communications work, and allied apparatus most of which, of course, are still enwrapped in military secrecy.

When the victory is attained, and it is possible to learn of the progress made by research and manufacture in this equipment, it will be found that an unbelievable amount of advancement has been made. And it will remain for the engineers to adapt these processes, which will be released, into the multitudinous articles and facilities for civilian consumption. Undoubtedly there will be many rough edges to be smoothed and we must, by no means, expect to reach perfection overnight. But the field is vast and fraught with innumerable possibilities.



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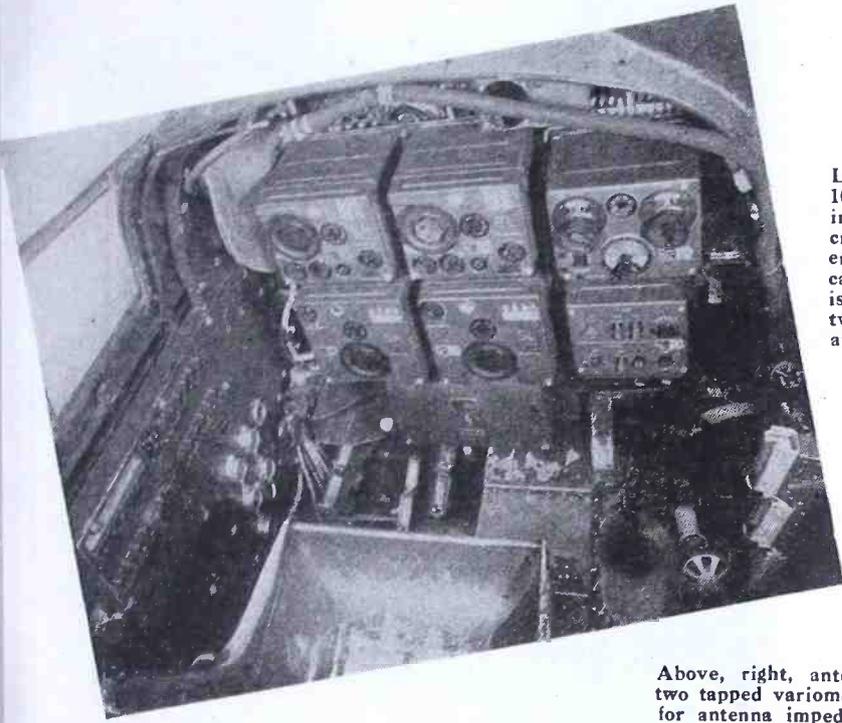
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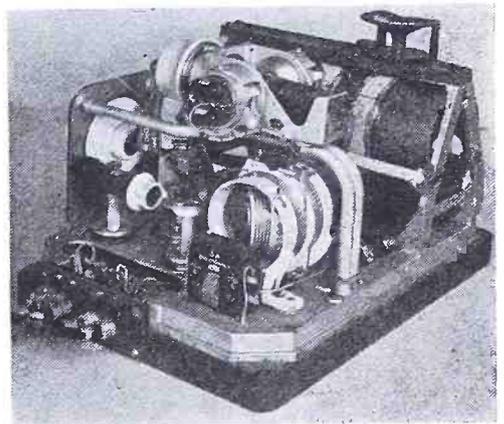
# ENEMY AIRBORNE RADIO

All photos courtesy British Air Ministry

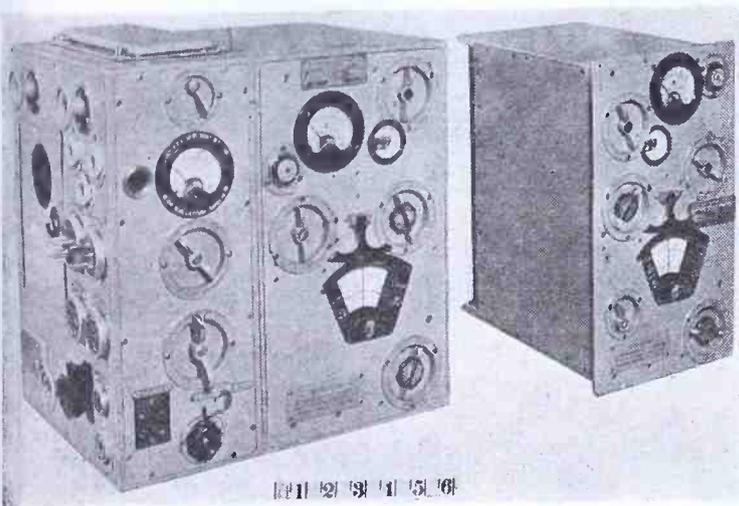
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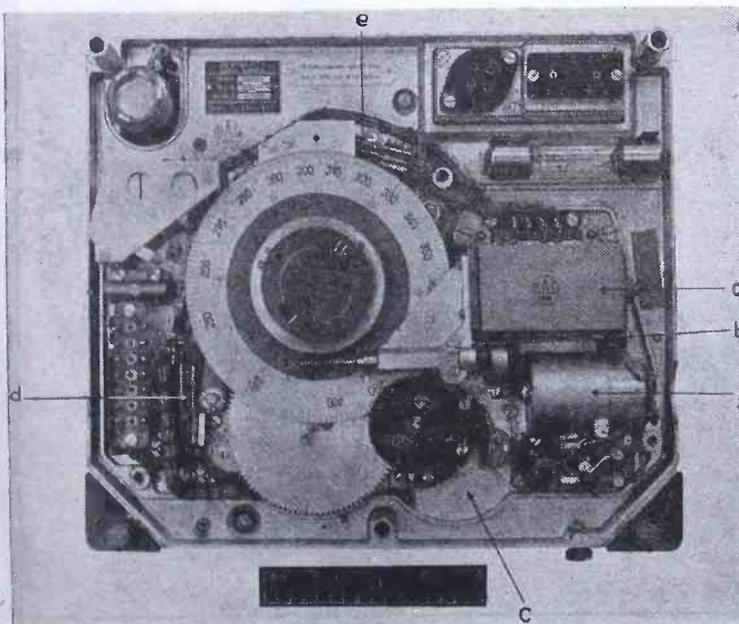
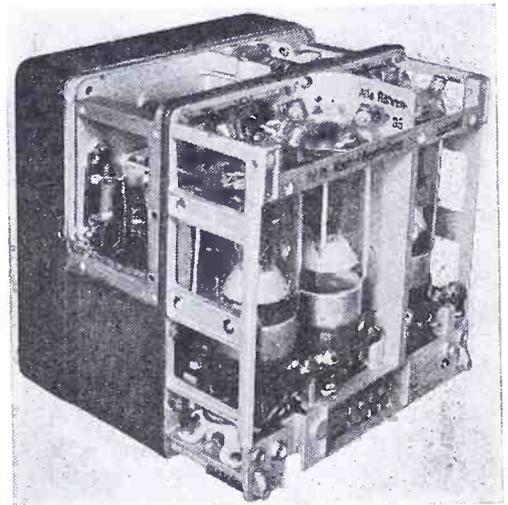
Left, Funk Gerät (FuG 10) equipment panel in Junkers 88 aircraft. This is a general purpose communications equipment and is used on bombers, twin-engined fighters and some flying boats.



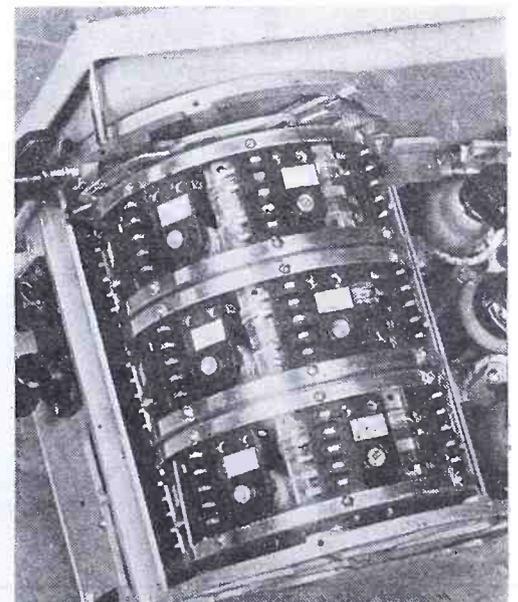
Above, right, antenna matching unit of the FuG 10 installation. In this section are two tapped variometers for tuning on h-f and m-f ranges, and iron-cored auto-transformers for antenna impedance matching to 50-ohm feeders. A vacuum type relay and current-transformer rectifier are also included. The unit weighs 18 pounds.



At left appears an Italian general purpose transmitter, type 350H. Covers 550-1119 and 820-1509 kc, and 3.5-9 mc. Triodes are used. Output in c-w is 10 to 20 watts. Right, FuG 10 transmitter with rear covers removed. Master oscillator used is Colpitts type.



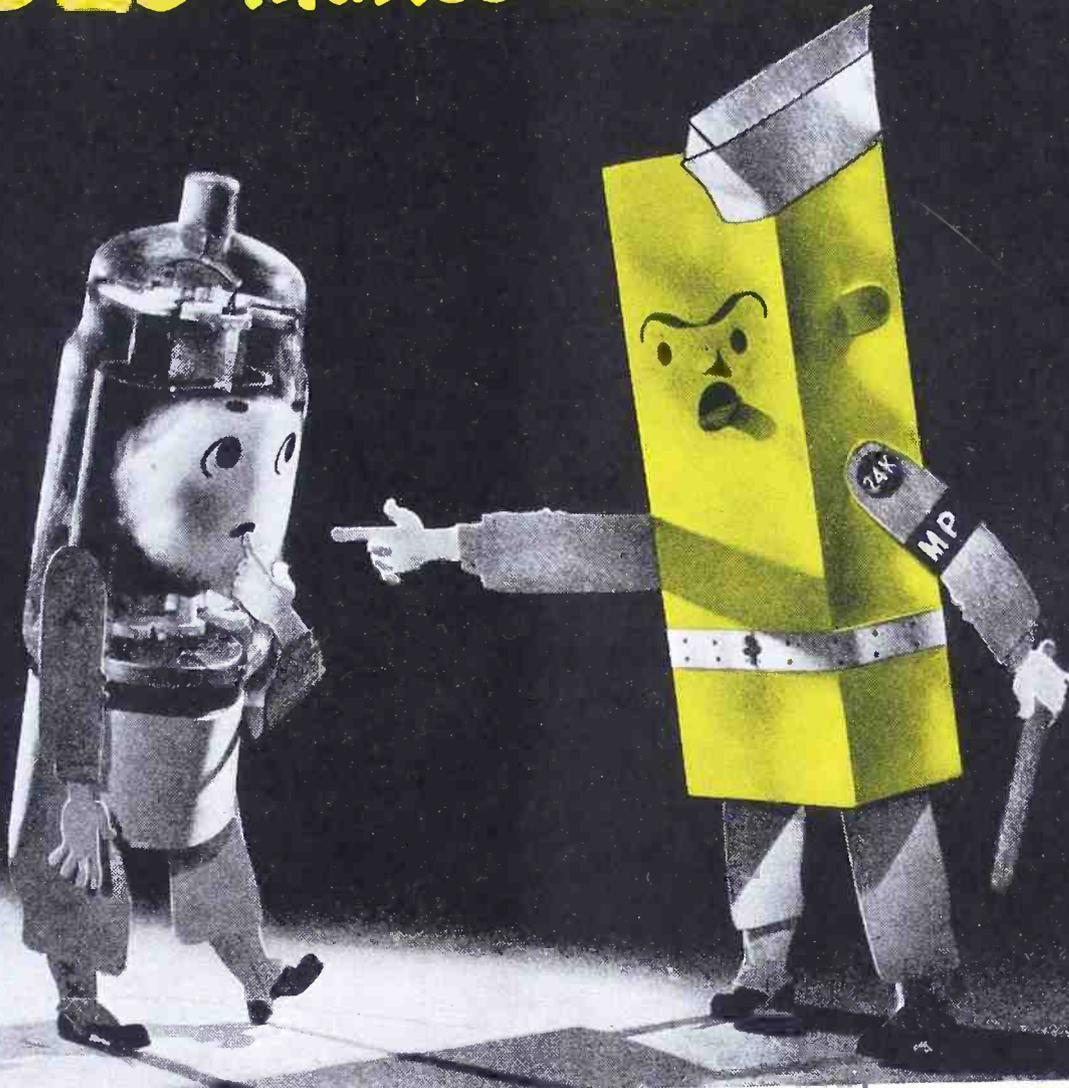
At left, German direction finding receiver, EZ4, used on single-engine dive bombers. Has electrical remote control system for 2-frequency selection. At *a*, electromagnet; *b*, armature carrying worm drive; *c*, manual tuning control; *d*, stopping contacts; *e*, reversing contacts; *f*, reversible motor. At right, interior of Italian receiver AR-8, with frequency range of from 200 kc to 22 mc, in seven continuous ranges. Also tunes from 520-700 kc. Single r-f is used, with all coils mounted on a 3-gang turret.



| No (db)                        | $\log \frac{1}{\epsilon} r$ | $\frac{1}{2} \log \frac{1}{\epsilon} r$ | $\frac{1}{2} \log \frac{1}{\epsilon} r$ | $2 \log \frac{1}{\epsilon} r$ | $\frac{1}{r}$       | $\epsilon^{-\theta}$ | $\left(\frac{1}{r}\right)^2$ | $r^2$                        | N                         | 2N                         | $N^2$                       | n                         | $\frac{n}{2}$              | No (db)                        |
|--------------------------------|-----------------------------|---|---|-------------------------------|---------------------|----------------------|------------------------------|------------------------------|---------------------------|----------------------------|-----------------------------|---------------------------|----------------------------|--------------------------------|
| $20 \log_{10} \epsilon \theta$ | $\theta$                    | $\frac{\theta}{2}$                      | $\frac{1}{2} \log \frac{1}{\epsilon} r$ | $2 \theta$                    | $\epsilon^{\theta}$ | $\epsilon^{-\theta}$ | $\epsilon^{2\theta}$         | $\epsilon^{-2\theta}$        | $(\epsilon^{\theta} - 1)$ | $2(\epsilon^{\theta} - 1)$ | $(\epsilon^{\theta} - 1)^2$ | $(\epsilon^{\theta} - 1)$ | $2(\epsilon^{\theta} - 1)$ | $20 \log_{10} \epsilon \theta$ |
| $20 \log_{10} k$               | $\log k_{\epsilon}$         | $\frac{1}{2} \log k_{\epsilon}$         | $\frac{1}{2} \log k_{\epsilon}$         | $2 \log k_{\epsilon}$         | k                   | $\frac{1}{k}$        | $k^2$                        | $\left(\frac{1}{k}\right)^2$ | $(k - 1)$                 | $2(k - 1)$                 | $(k - 1)^2$                 | $(k - 1)$                 | $2(k - 1)$                 | $20 \log_{10} k$               |
| 0.00                           | 0.0000000                   | 0.0000000                               | 0.0000000                               | 0.0000000                     | 1.000000            | 1.000000             | 1.000000                     | 1.000000                     | 0.000000                  | 0.000000                   | 0.000000                    | ∞                         | ∞                          | 0.00                           |
| 0.01                           | 0.001513                    | 0.0007565                               | 0.0007565                               | 0.003026                      | 0.99849             | 0.99700              | 0.99700                      | 0.99700                      | 0.0015                    | 0.0030                     | 1.3225x10 <sup>-6</sup>     | 868.76                    | 434.38                     | 0.01                           |
| 0.02                           | 0.003026                    | 0.001513                                | 0.001513                                | 0.006052                      | 0.99699             | 0.99500              | 0.99500                      | 0.99500                      | 0.0030                    | 0.0060                     | 5.2900x10 <sup>-6</sup>     | 433.72                    | 216.86                     | 0.02                           |
| 0.03                           | 0.004539                    | 0.0022695                               | 0.0022695                               | 0.009078                      | 0.99658             | 0.99416              | 0.99416                      | 0.99416                      | 0.0045                    | 0.0090                     | 1.19716x10 <sup>-5</sup>    | 289.02                    | 144.51                     | 0.03                           |
| 0.04                           | 0.006052                    | 0.003026                                | 0.003026                                | 0.012104                      | 0.99617             | 0.99332              | 0.99332                      | 0.99332                      | 0.0060                    | 0.0120                     | 2.13449x10 <sup>-5</sup>    | 217.66                    | 108.83                     | 0.04                           |
| 0.05                           | 0.007565                    | 0.0037825                               | 0.0037825                               | 0.015130                      | 0.99577             | 0.99250              | 0.99250                      | 0.99250                      | 0.0075                    | 0.0150                     | 3.32929x10 <sup>-5</sup>    | 173.20                    | 86.60                      | 0.05                           |
| 0.06                           | 0.009078                    | 0.004539                                | 0.004539                                | 0.018156                      | 0.99536             | 0.99116              | 0.99116                      | 0.99116                      | 0.0090                    | 0.0180                     | 4.80249x10 <sup>-5</sup>    | 144.26                    | 72.13                      | 0.06                           |
| 0.07                           | 0.010591                    | 0.0052955                               | 0.0052955                               | 0.021182                      | 0.99495             | 0.99099              | 0.99099                      | 0.99099                      | 0.0105                    | 0.0210                     | 6.54481x10 <sup>-5</sup>    | 123.59                    | 61.79                      | 0.07                           |
| 0.08                           | 0.012104                    | 0.006052                                | 0.006052                                | 0.024208                      | 0.99454             | 0.99011              | 0.99011                      | 0.99011                      | 0.0121                    | 0.0240                     | 8.55625x10 <sup>-5</sup>    | 108.07                    | 54.03                      | 0.08                           |
| 0.09                           | 0.013617                    | 0.006809                                | 0.006809                                | 0.027234                      | 0.99413             | 0.98962              | 0.98962                      | 0.98962                      | 0.0136                    | 0.0270                     | 1.08576x10 <sup>-4</sup>    | 96.009                    | 48.004                     | 0.09                           |
| 0.10                           | 0.015130                    | 0.007565                                | 0.007565                                | 0.030260                      | 0.99372             | 0.98911              | 0.98911                      | 0.98911                      | 0.0151                    | 0.0300                     | 0.0013410                   | 86.361                    | 43.180                     | 0.10                           |
| 0.11                           | 0.016643                    | 0.008322                                | 0.008322                                | 0.033286                      | 0.99331             | 0.98860              | 0.98860                      | 0.98860                      | 0.0166                    | 0.0330                     | 0.0016256                   | 78.461                    | 39.230                     | 0.11                           |
| 0.12                           | 0.018156                    | 0.009078                                | 0.009078                                | 0.036312                      | 0.99290             | 0.98809              | 0.98809                      | 0.98809                      | 0.0181                    | 0.0360                     | 0.0019349                   | 71.883                    | 35.941                     | 0.12                           |
| 0.13                           | 0.019669                    | 0.009835                                | 0.009835                                | 0.039338                      | 0.99249             | 0.98758              | 0.98758                      | 0.98758                      | 0.0196                    | 0.0390                     | 0.0022741                   | 66.317                    | 33.158                     | 0.13                           |
| 0.14                           | 0.021182                    | 0.010591                                | 0.010591                                | 0.042364                      | 0.99208             | 0.98707              | 0.98707                      | 0.98707                      | 0.0211                    | 0.0420                     | 0.0026406                   | 61.543                    | 30.771                     | 0.14                           |
| 0.15                           | 0.022695                    | 0.011348                                | 0.011348                                | 0.045390                      | 0.99167             | 0.98656              | 0.98656                      | 0.98656                      | 0.0226                    | 0.0450                     | 0.0030380                   | 57.408                    | 28.704                     | 0.15                           |
| 0.16                           | 0.024208                    | 0.012104                                | 0.012104                                | 0.048416                      | 0.99126             | 0.98605              | 0.98605                      | 0.98605                      | 0.0242                    | 0.0480                     | 0.0034559                   | 53.787                    | 26.893                     | 0.16                           |
| 0.17                           | 0.025721                    | 0.012861                                | 0.012861                                | 0.051442                      | 0.99085             | 0.98554              | 0.98554                      | 0.98554                      | 0.0257                    | 0.0510                     | 0.0038985                   | 50.596                    | 25.298                     | 0.17                           |
| 0.18                           | 0.027234                    | 0.013617                                | 0.013617                                | 0.054468                      | 0.99044             | 0.98503              | 0.98503                      | 0.98503                      | 0.0272                    | 0.0540                     | 0.0043848                   | 47.755                    | 23.877                     | 0.18                           |
| 0.19                           | 0.028747                    | 0.014374                                | 0.014374                                | 0.057494                      | 0.99003             | 0.98452              | 0.98452                      | 0.98452                      | 0.0287                    | 0.0570                     | 0.0048929                   | 45.218                    | 22.604                     | 0.19                           |
| 0.20                           | 0.030260                    | 0.015130                                | 0.015130                                | 0.060520                      | 0.98962             | 0.98401              | 0.98401                      | 0.98401                      | 0.0302                    | 0.0600                     | 0.005425                    | 42.931                    | 21.465                     | 0.20                           |
| 0.25                           | 0.037825                    | 0.018912                                | 0.018912                                | 0.075650                      | 0.98819             | 0.98258              | 0.98258                      | 0.98258                      | 0.0378                    | 0.0750                     | 0.008515                    | 34.245                    | 17.122                     | 0.25                           |
| 0.30                           | 0.045390                    | 0.022695                                | 0.022695                                | 0.090780                      | 0.98676             | 0.98116              | 0.98116                      | 0.98116                      | 0.0453                    | 0.0900                     | 0.012350                    | 28.455                    | 14.227                     | 0.30                           |
| 0.35                           | 0.048091                    | 0.024045                                | 0.024045                                | 0.096180                      | 0.98533             | 0.97973              | 0.97973                      | 0.97973                      | 0.0480                    | 0.0960                     | 0.016907                    | 24.320                    | 12.160                     | 0.35                           |
| 0.40                           | 0.050792                    | 0.025390                                | 0.025390                                | 0.101570                      | 0.98390             | 0.97830              | 0.97830                      | 0.97830                      | 0.0507                    | 0.1010                     | 0.022210                    | 21.219                    | 10.608                     | 0.40                           |
| 0.50                           | 0.057565                    | 0.028782                                | 0.028782                                | 0.115120                      | 0.98147             | 0.97587              | 0.97587                      | 0.97587                      | 0.0575                    | 0.1150                     | 0.035110                    | 16.877                    | 8.438                      | 0.50                           |
| 0.60                           | 0.063322                    | 0.031661                                | 0.031661                                | 0.128670                      | 0.97904             | 0.97344              | 0.97344                      | 0.97344                      | 0.0633                    | 0.1280                     | 0.051151                    | 13.982                    | 6.991                      | 0.60                           |
| 0.70                           | 0.069078                    | 0.034539                                | 0.034539                                | 0.142220                      | 0.97661             | 0.97099              | 0.97099                      | 0.97099                      | 0.0690                    | 0.1420                     | 0.070439                    | 11.915                    | 5.457                      | 0.70                           |
| 0.80                           | 0.074835                    | 0.037416                                | 0.037416                                | 0.155770                      | 0.97418             | 0.96856              | 0.96856                      | 0.96856                      | 0.0748                    | 0.1550                     | 0.093079                    | 10.365                    | 5.182                      | 0.80                           |
| 0.90                           | 0.080591                    | 0.040293                                | 0.040293                                | 0.169320                      | 0.97175             | 0.96613              | 0.96613                      | 0.96613                      | 0.0805                    | 0.1690                     | 0.11918                     | 9.1600                    | 4.580                      | 0.90                           |
| 1.00                           | 0.086348                    | 0.043170                                | 0.043170                                | 0.182870                      | 0.96932             | 0.96370              | 0.96370                      | 0.96370                      | 0.0863                    | 0.1820                     | 0.14889                     | 8.1954                    | 4.0977                     | 1.00                           |
| 1.10                           | 0.092104                    | 0.046047                                | 0.046047                                | 0.196420                      | 0.96690             | 0.96128              | 0.96128                      | 0.96128                      | 0.0921                    | 0.1960                     | 0.18202                     | 7.4069                    | 3.7039                     | 1.10                           |
| 1.20                           | 0.097861                    | 0.048924                                | 0.048924                                | 0.210000                      | 0.96447             | 0.95885              | 0.95885                      | 0.95885                      | 0.0978                    | 0.2100                     | 0.21948                     | 6.7499                    | 3.3749                     | 1.20                           |
| 1.30                           | 0.103617                    | 0.051801                                | 0.051801                                | 0.223550                      | 0.96204             | 0.95642              | 0.95642                      | 0.95642                      | 0.1036                    | 0.2230                     | 0.26066                     | 6.1939                    | 3.0969                     | 1.30                           |
| 1.40                           | 0.109374                    | 0.054678                                | 0.054678                                | 0.237100                      | 0.95961             | 0.95400              | 0.95400                      | 0.95400                      | 0.1093                    | 0.2370                     | 0.30590                     | 5.7176                    | 2.8588                     | 1.40                           |
| 1.50                           | 0.115130                    | 0.057555                                | 0.057555                                | 0.250650                      | 0.95718             | 0.95157              | 0.95157                      | 0.95157                      | 0.1151                    | 0.2500                     | 0.35532                     | 5.3050                    | 2.6025                     | 1.50                           |
| 1.60                           | 0.120887                    | 0.060432                                | 0.060432                                | 0.264200                      | 0.95475             | 0.94914              | 0.94914                      | 0.94914                      | 0.1208                    | 0.2640                     | 0.40993                     | 4.9439                    | 2.4719                     | 1.60                           |
| 1.70                           | 0.126643                    | 0.063309                                | 0.063309                                | 0.277750                      | 0.95232             | 0.94671              | 0.94671                      | 0.94671                      | 0.1266                    | 0.2770                     | 0.46973                     | 4.6258                    | 2.3129                     | 1.70                           |
| 1.80                           | 0.132399                    | 0.066186                                | 0.066186                                | 0.291300                      | 0.94989             | 0.94428              | 0.94428                      | 0.94428                      | 0.1323                    | 0.2910                     | 0.53424                     | 4.3427                    | 2.1713                     | 1.80                           |
| 1.90                           | 0.138156                    | 0.069063                                | 0.069063                                | 0.304850                      | 0.94746             | 0.94185              | 0.94185                      | 0.94185                      | 0.1381                    | 0.3040                     | 0.60390                     | 4.0897                    | 2.0448                     | 1.90                           |
| 2.00                           | 0.143912                    | 0.071940                                | 0.071940                                | 0.318400                      | 0.94503             | 0.93942              | 0.93942                      | 0.93942                      | 0.1439                    | 0.3180                     | 0.67845                     | 3.8620                    | 1.9310                     | 2.00                           |
| 2.10                           | 0.149668                    | 0.074817                                | 0.074817                                | 0.331950                      | 0.94260             | 0.93700              | 0.93700                      | 0.93700                      | 0.1496                    | 0.3310                     | 0.75800                     | 3.6563                    | 1.8281                     | 2.10                           |
| 2.20                           | 0.155424                    | 0.077694                                | 0.077694                                | 0.345500                      | 0.94017             | 0.93457              | 0.93457                      | 0.93457                      | 0.1554                    | 0.3450                     | 0.84255                     | 3.4692                    | 1.7346                     | 2.20                           |
| 2.30                           | 0.161180                    | 0.080571                                | 0.080571                                | 0.359050                      | 0.93774             | 0.93214              | 0.93214                      | 0.93214                      | 0.1611                    | 0.3590                     | 0.93210                     | 3.2985                    | 1.6492                     | 2.30                           |
| 2.40                           | 0.166936                    | 0.083448                                | 0.083448                                | 0.372600                      | 0.93531             | 0.92971              | 0.92971                      | 0.92971                      | 0.1669                    | 0.3720                     | 1.02465                     | 3.1421                    | 1.5710                     | 2.40                           |
| 2.50                           | 0.172692                    | 0.086325                                | 0.086325                                | 0.386150                      | 0.93288             | 0.92728              | 0.92728                      | 0.92728                      | 0.1726                    | 0.3860                     | 1.12120                     | 2.9983                    | 1.4998                     | 2.50                           |
| 2.60                           | 0.178448                    | 0.089202                                | 0.089202                                | 0.399700                      | 0.93045             | 0.92485              | 0.92485                      | 0.92485                      | 0.1784                    | 0.3990                     | 1.22175                     | 2.8657                    | 1.4328                     | 2.60                           |
| 2.70                           | 0.184204                    | 0.092079                                | 0.092079                                | 0.413250                      | 0.92802             | 0.92242              | 0.92242                      | 0.92242                      | 0.1842                    | 0.4130                     | 1.32530                     | 2.7429                    | 1.3714                     | 2.70                           |
| 2.80                           | 0.189960                    | 0.094956                                | 0.094956                                | 0.426800                      | 0.92559             | 0.92000              | 0.92000                      | 0.92000                      | 0.1899                    | 0.4260                     | 1.43285                     | 2.6289                    | 1.3144                     | 2.80                           |
| 2.90                           | 0.195716                    | 0.097833                                | 0.097833                                | 0.440350                      | 0.92316             | 0.91757              | 0.91757                      | 0.91757                      | 0.1957                    | 0.4400                     | 1.54440                     | 2.5229                    | 1.2614                     | 2.90                           |
| 3.00                           | 0.201472                    | 0.100710                                | 0.100710                                | 0.453900                      | 0.92073             | 0.91514              | 0.91514                      | 0.91514                      | 0.2014                    | 0.4530                     | 1.66095                     | 2.4240                    | 1.2120                     | 3.00                           |
| 3.10                           | 0.207228                    | 0.103587                                | 0.103587                                | 0.467450                      | 0.91830             | 0.91271              | 0.91271                      | 0.91271                      | 0.2072                    | 0.4670                     | 1.78250                     | 2.3260                    | 1.1658                     | 3.10                           |
| 3.20                           | 0.212984                    | 0.106464                                | 0.106464                                | 0.481000                      | 0.91587             | 0.91028              | 0.91028                      | 0.91028                      | 0.2129                    | 0.4810                     | 1.90905                     | 2.2350                    | 1.1225                     | 3.20                           |
| 3.30                           | 0.218740                    | 0.109341                                | 0.109341                                | 0.494550                      | 0.91344             | 0.90785              | 0.90785                      | 0.90785                      | 0.2187                    | 0.4940                     | 2.04060                     | 2.1490                    | 1.0819                     | 3.30                           |
| 3.40                           | 0.224496                    | 0.112218                                | 0.112218                                | 0.508100                      | 0.91101             | 0.90542              | 0.90542                      | 0.90542                      | 0.2244                    | 0.5080                     | 2.17715                     | 2.0670                    | 1.0436                     | 3.40                           |

Basic data from which all of the hyperbolic functions of a real variable required for the design of purely resistive networks may be obtained. (Continued on page 54)

# GOLD makes Electrons Behave



It was a great day for radio communication when National Union engineers developed the technique of gold plating certain tube parts. For by this ingenious means they measurably extended the life of power tubes.

The object, here, was not to make power tubes structurally stronger—or even more durable. Already these tubes were sound enough mechanically to do a bang-up job. What the N. U. process of gold plating did, was to make the electrons behave. N. U. engineers demonstrated that by gold-plating the grid wire, they automatically eliminated a very disturbing factor in power tube performance, known as

grid emission. The source of this undesirable primary emission was imprisoned within the gold. No longer could it interfere with the planned and controlled electron flow within the tube. Result—power tubes of a higher performance level and longer life.

Thanks to the greatly expanded electronic research program at National Union Laboratories, many such improved tubes with wide application in America's homes and industries will be available at the war's end. *Count on National Union.*

**NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.**  
Factories: Newark and Maplewood, N. J.; Lansdale and Robesonia, Pa.



# NATIONAL UNION

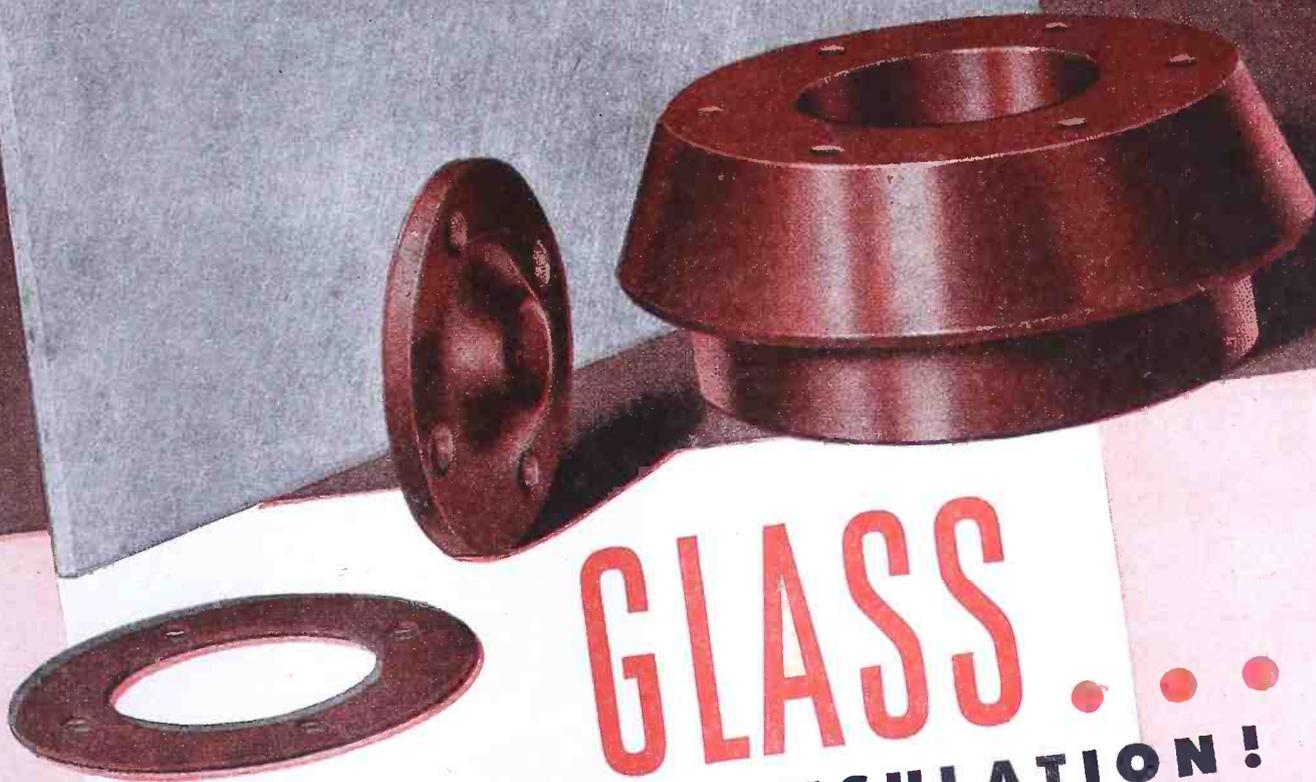
# RADIO AND ELECTRONIC TUBES

Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

(Continued from page 52)

| No (db)                        | $\log \frac{1}{\epsilon} r$ | $\frac{1}{2} \log \frac{1}{\epsilon} r$ | $\frac{1}{2} \log \frac{1}{\epsilon} r$ | $\frac{1}{\epsilon} r$ | $\frac{1}{r}$        | $\frac{1}{r}$        | $\left(\frac{1}{r}\right)^2$ | $r^2$                        | N                       | 2N                       | $N^2$                     | n                                 | $\frac{n}{2}$                      | No (db)                        |
|--------------------------------|-----------------------------|---|---|------------------------|----------------------|----------------------|------------------------------|------------------------------|-------------------------|--------------------------|---------------------------|-----------------------------------|------------------------------------|--------------------------------|
| $20 \log_{10} \epsilon^\theta$ | $\theta$                    | $\frac{\theta}{2}$                      | $2 \log \frac{1}{\epsilon} r$           | $\epsilon^\theta$      | $\epsilon^{-\theta}$ | $\epsilon^{2\theta}$ | $\left(\frac{1}{k}\right)^2$ | $\epsilon^{-2\theta}$        | $(\epsilon^\theta - 1)$ | $2(\epsilon^\theta - 1)$ | $(\epsilon^\theta - 1)^2$ | $\frac{1}{(\epsilon^\theta - 1)}$ | $\frac{1}{2(\epsilon^\theta - 1)}$ | $20 \log_{10} \epsilon^\theta$ |
| $20 \log_{10} k$               | $\log k$                    | $\frac{1}{2} \log k$                    | $2 \log k$                              | k                      | $\frac{1}{k}$        | $k^2$                | $\left(\frac{1}{k}\right)^2$ | $\left(\frac{1}{k}\right)^2$ | $(k-1)$                 | $2(k-1)$                 | $(k-1)^2$                 | $\frac{1}{(k-1)}$                 | $\frac{1}{2(k-1)}$                 | $20 \log_{10} k$               |
| 3.5                            | .40295                      | .20148                                  | .80590                                  | 1.49623                | .66834               | 2.23872              | .446684                      | .446684                      | .49623                  | .99246                   | .246244                   | 2.0152                            | 1.0076                             | 3.5                            |
| 3.6                            | .41447                      | .20723                                  | .82894                                  | 1.51356                | .66069               | 2.29087              | .437516                      | .437516                      | .51356                  | 1.02712                  | .263744                   | 1.9472                            | 0.9736                             | 3.6                            |
| 3.7                            | .42598                      | .21299                                  | .85198                                  | 1.53109                | .65313               | 2.34423              | .426589                      | .426589                      | .53109                  | 1.06218                  | .282057                   | 1.8829                            | .9414                              | 3.7                            |
| 3.8                            | .43749                      | .21875                                  | .87498                                  | 1.54882                | .64565               | 2.39883              | .416869                      | .416869                      | .54882                  | 1.09644                  | .300545                   | 1.8221                            | .9110                              | 3.8                            |
| 3.9                            | .44900                      | .22450                                  | .89800                                  | 1.56674                | .63827               | 2.45471              | .407380                      | .407380                      | .56674                  | 1.13348                  | .321194                   | 1.7644                            | .8822                              | 3.9                            |
| 4.0                            | .46052                      | .23026                                  | .92104                                  | 1.58489                | .63096               | 2.51189              | .398107                      | .398107                      | .58489                  | 1.16978                  | .342096                   | 1.7097                            | .8548                              | 4.0                            |
| 4.5                            | .51808                      | .25904                                  | 1.03616                                 | 1.67880                | .59566               | 3.54813              | .316228                      | .316228                      | .67880                  | 1.35760                  | .460769                   | 1.4732                            | .7366                              | 4.5                            |
| 5.0                            | .57565                      | .28782                                  | 1.15130                                 | 1.77828                | .56234               | 3.16228              | .281838                      | .281838                      | .77828                  | 1.55656                  | .605720                   | 1.2849                            | .6424                              | 5.0                            |
| 5.5                            | .63321                      | .31661                                  | 1.26642                                 | 1.88365                | .53088               | 3.54813              | .251189                      | .251189                      | .88365                  | 1.76730                  | .780837                   | 1.1317                            | .5658                              | 5.5                            |
| 6.0                            | .69078                      | .34539                                  | 1.38156                                 | 1.99526                | .50119               | 3.98107              | .221838                      | .221838                      | .99526                  | 1.99052                  | .990542                   | 1.0048                            | .5024                              | 6.0                            |
| 6.5                            | .74834                      | .37417                                  | 1.49668                                 | 2.11349                | .47315               | 4.46684              | .200000                      | .200000                      | 1.1135                  | 2.2270                   | 1.23988                   | .89807                            | .44903                             | 6.5                            |
| 7.0                            | .80590                      | .40295                                  | 1.61180                                 | 2.23872                | .44668               | 5.01187              | .18184                       | .18184                       | 1.2387                  | 2.4774                   | 1.53438                   | .80730                            | .40365                             | 7.0                            |
| 7.5                            | .86347                      | .43173                                  | 1.72694                                 | 2.37137                | .42170               | 5.62342              | .166072                      | .166072                      | 1.3714                  | 2.7428                   | 1.88074                   | .72918                            | .36459                             | 7.5                            |
| 8.0                            | .92103                      | .46052                                  | 1.84206                                 | 2.51189                | .39811               | 6.30957              | .15119                       | .15119                       | 1.5119                  | 3.0238                   | 2.28584                   | .66142                            | .33071                             | 8.0                            |
| 8.5                            | .97860                      | .48930                                  | 1.95720                                 | 2.66072                | .37584               | 7.07946              | .141254                      | .141254                      | 1.6607                  | 3.3214                   | 2.75792                   | .60216                            | .30108                             | 8.5                            |
| 9.0                            | 1.03616                     | .51808                                  | 2.07232                                 | 2.81838                | .35481               | 7.94327              | .132892                      | .132892                      | 1.8184                  | 3.6368                   | 3.30658                   | .54993                            | .27496                             | 9.0                            |
| 9.5                            | 1.09373                     | .54686                                  | 2.18746                                 | 2.98107                | .33497               | 8.91251              | .12537                       | .12537                       | 1.9811                  | 3.9708                   | 3.55473                   | .50368                            | .25184                             | 9.5                            |
| 10.0                           | 1.15129                     | .57565                                  | 2.30258                                 | 3.16228                | .31623               | 10.00000             | .118838                      | .118838                      | 2.1623                  | 4.3246                   | 4.67554                   | .46247                            | .23123                             | 10.0                           |
| 10.5                           | 1.20886                     | .60443                                  | 2.41772                                 | 3.34965                | .29854               | 11.22018             | .112018                      | .112018                      | 2.3497                  | 4.6994                   | 5.52109                   | .42559                            | .21279                             | 10.5                           |
| 11.0                           | 1.26642                     | .63321                                  | 2.53284                                 | 3.54813                | .28184               | 12.58924             | .1069125                     | .1069125                     | 2.5481                  | 5.0962                   | 6.49281                   | .39245                            | .19622                             | 11.0                           |
| 11.5                           | 1.32399                     | .66199                                  | 2.64798                                 | 3.75837                | .26607               | 14.12537             | .102387                      | .102387                      | 2.7584                  | 5.5168                   | 7.60877                   | .36253                            | .18126                             | 11.5                           |
| 12.0                           | 1.38155                     | .69078                                  | 2.76310                                 | 3.98107                | .25119               | 15.84893             | .09794                       | .09794                       | 2.9811                  | 5.9622                   | 8.88696                   | .33545                            | .16772                             | 12.0                           |
| 12.5                           | 1.43912                     | .71956                                  | 2.87824                                 | 4.21782                | .23714               | 17.78279             | .0936234                     | .0936234                     | 3.2170                  | 6.4340                   | 10.3491                   | .31085                            | .15542                             | 12.5                           |
| 13.0                           | 1.49668                     | .74834                                  | 2.99336                                 | 4.46684                | .22387               | 19.95262             | .090119                      | .090119                      | 3.4668                  | 6.9336                   | 12.0187                   | .28845                            | .14422                             | 13.0                           |
| 13.5                           | 1.55425                     | .77712                                  | 3.10850                                 | 4.73151                | .21135               | 22.38722             | .086668                      | .086668                      | 3.7315                  | 7.4630                   | 13.9241                   | .26799                            | .13399                             | 13.5                           |
| 14.0                           | 1.61181                     | .80590                                  | 3.22362                                 | 5.01187                | .20193               | 25.11887             | .083311                      | .083311                      | 4.0119                  | 8.0238                   | 16.0953                   | .24926                            | .12463                             | 14.0                           |
| 14.5                           | 1.66937                     | .83469                                  | 3.33874                                 | 5.30884                | .18836               | 28.18383             | .0801481                     | .0801481                     | 4.3088                  | 8.6176                   | 18.5658                   | .23208                            | .11604                             | 14.5                           |
| 15.0                           | 1.72694                     | .86347                                  | 3.45388                                 | 5.62342                | .17783               | 31.62278             | .077183                      | .077183                      | 4.6234                  | 9.2468                   | 21.3758                   | .21629                            | .10814                             | 15.0                           |
| 15.5                           | 1.78450                     | .89225                                  | 3.56900                                 | 5.95662                | .16788               | 35.48134             | .074366                      | .074366                      | 4.9566                  | 9.9132                   | 24.5679                   | .20175                            | .10087                             | 15.5                           |
| 16.0                           | 1.84207                     | .92103                                  | 3.68414                                 | 6.30957                | .15849               | 39.81072             | .071850                      | .071850                      | 5.3096                  | 10.6192                  | 28.1918                   | .18834                            | .09417                             | 16.0                           |
| 16.5                           | 1.89963                     | .94982                                  | 3.79926                                 | 6.68344                | .14962               | 44.66836             | .069433                      | .069433                      | 5.6834                  | 11.3668                  | 32.3010                   | .17595                            | .08797                             | 16.5                           |
| 17.0                           | 1.95720                     | .97860                                  | 3.91440                                 | 7.07946                | .14125               | 50.11874             | .067595                      | .067595                      | 6.0795                  | 12.1590                  | 36.9603                   | .16449                            | .08224                             | 17.0                           |
| 17.5                           | 2.01476                     | 1.00738                                 | 4.02952                                 | 7.49895                | .13335               | 56.23416             | .065989                      | .065989                      | 6.4989                  | 12.9978                  | 42.2357                   | .15387                            | .07693                             | 17.5                           |
| 18.0                           | 2.07233                     | 1.03616                                 | 4.14466                                 | 7.94327                | .12589               | 63.09565             | .064549                      | .064549                      | 6.9433                  | 13.8866                  | 48.2094                   | .14402                            | .07201                             | 18.0                           |
| 18.5                           | 2.12989                     | 1.06495                                 | 4.25978                                 | 8.41394                | .118850              | 70.79459             | .0632119                     | .0632119                     | 7.4139                  | 14.8278                  | 54.9659                   | .13488                            | .06744                             | 18.5                           |
| 19.0                           | 2.18746                     | 1.09373                                 | 4.37492                                 | 8.91251                | .112202              | 79.43273             | .061935                      | .061935                      | 7.9135                  | 15.8270                  | 62.6235                   | .12638                            | .06319                             | 19.0                           |
| 19.5                           | 2.24502                     | 1.12251                                 | 4.49004                                 | 9.44061                | .105925              | 89.12510             | .060712                      | .060712                      | 8.4406                  | 16.8812                  | 71.2437                   | .11847                            | .05923                             | 19.5                           |
| 20.0                           | 2.30258                     | 1.15129                                 | 4.60516                                 | 10.00000               | .100000              | 100.00000            | .059589                      | .059589                      | 9.0000                  | 18.0000                  | 81.0000                   | .11111                            | .05556                             | 20.0                           |
| 20.5                           | 2.36015                     | 1.18007                                 | 4.72030                                 | 10.59255               | .094406              | 112.2018             | .058519                      | .058519                      | 9.5925                  | 19.1850                  | 92.0161                   | .10425                            | .05212                             | 20.5                           |
| 21.0                           | 2.41771                     | 1.20886                                 | 4.83542                                 | 11.22018               | .089125              | 125.8924             | .057595                      | .057595                      | 10.2202                 | 20.4404                  | 106.0445                  | .09785                            | .04892                             | 21.0                           |
| 21.5                           | 2.47528                     | 1.23764                                 | 4.95056                                 | 11.88503               | .084139              | 141.5440             | .056795                      | .056795                      | 10.8850                 | 21.7700                  | 118.4832                  | .09187                            | .04593                             | 21.5                           |
| 22.0                           | 2.53284                     | 1.26642                                 | 5.06568                                 | 12.58924               | .079433              | 158.4893             | .056096                      | .056096                      | 11.5892                 | 23.1784                  | 134.3049                  | .08629                            | .04314                             | 22.0                           |
| 22.5                           | 2.59041                     | 1.29520                                 | 5.18082                                 | 13.33524               | .074989              | 177.8279             | .0554234                     | .0554234                     | 12.3352                 | 24.6704                  | 152.1522                  | .08107                            | .04053                             | 22.5                           |
| 23.0                           | 2.64797                     | 1.32399                                 | 5.29594                                 | 14.12537               | .070795              | 199.5262             | .054819                      | .054819                      | 13.1254                 | 26.2508                  | 172.2656                  | .07619                            | .03809                             | 23.0                           |
| 23.5                           | 2.70554                     | 1.35277                                 | 5.41108                                 | 14.96234               | .066834              | 223.8722             | .054268                      | .054268                      | 13.9623                 | 27.9246                  | 194.9374                  | .07162                            | .03581                             | 23.5                           |
| 24.0                           | 2.76310                     | 1.38155                                 | 5.52620                                 | 15.84893               | .063096              | 251.1887             | .053711                      | .053711                      | 14.8489                 | 29.6978                  | 220.4928                  | .06734                            | .03367                             | 24.0                           |
| 24.5                           | 2.82067                     | 1.41033                                 | 5.64134                                 | 16.78803               | .059566              | 281.8383             | .0531481                     | .0531481                     | 15.7880                 | 31.5760                  | 249.2609                  | .06334                            | .03167                             | 24.5                           |
| 25.0                           | 2.87823                     | 1.43912                                 | 5.75646                                 | 17.78279               | .056234              | 316.2278             | .0525824                     | .0525824                     | 16.7828                 | 33.5656                  | 281.6691                  | .05958                            | .02979                             | 25.0                           |
| 25.5                           | 2.93580                     | 1.46790                                 | 5.87160                                 | 18.83649               | .053088              | 354.8134             | .0520184                     | .0520184                     | 17.8364                 | 35.6728                  | 318.1229                  | .05607                            | .02803                             | 25.5                           |
| 26.0                           | 2.99336                     | 1.49668                                 | 5.98672                                 | 19.95262               | .050119              | 398.1072             | .051459                      | .051459                      | 18.9526                 | 37.9052                  | 359.2162                  | .05276                            | .02638                             | 26.0                           |
| 26.5                           | 3.05093                     | 1.52546                                 | 6.10186                                 | 21.13490               | .047315              | 446.6836             | .050891                      | .050891                      | 20.1349                 | 40.2698                  | 405.4182                  | .04966                            | .02483                             | 26.5                           |
| 27.0                           | 3.10849                     | 1.55424                                 | 6.21698                                 | 22.38722               | .044668              | 501.1874             | .0503481                     | .0503481                     | 21.3872                 | 42.7744                  | 458.4038                  | .04676                            | .02338                             | 27.0                           |
| 27.5                           | 3.16605                     | 1.58303                                 | 6.33210                                 | 23.71372               | .042170              | 562.3416             | .0498173                     | .0498173                     | 22.7137                 | 45.4274                  | 515.9258                  | .04403                            | .02201                             | 27.5                           |
| 28.0                           | 3.22362                     | 1.61181                                 | 6.44724                                 | 25.11887               | .039811              | 630.9565             | .0493150                     | .0493150                     | 24.1189                 | 48.2378                  | 581.7262                  | .04146                            | .02073                             | 28.0                           |
| 28.5                           | 3.28118                     | 1.64059                                 | 6.56236                                 | 26.60723               | .037584              | 707.9457             | .0488125                     | .0488125                     | 25.6072                 | 51.2144                  | 655.7184                  | .03905                            | .01952                             | 28.5                           |

Basic data from which all of the hyperbolic functions of a real variable required for the design of purely resistive networks may be obtained. (Continued on page 56)



# GLASS . . .

## FOR LOW LOSS INSULATION!

● When glass is used as the fibrous component in Formica laminated plastic sheets, tubes and rods the material becomes a low loss insulator comparable to ceramics, and capable of replacing ceramics for many uses. At the same time it retains typical Formica characteristics, of machinability and adaptation to rapid production processes.

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| No (db)                 | $\log \frac{1}{\epsilon} r$ | $\frac{1}{2} \log \frac{1}{\epsilon} r$ | $2 \log \frac{1}{\epsilon} r$ | $\frac{1}{r}$             | $\frac{1}{\epsilon}$      | $\left(\frac{1}{r}\right)^2$ | $r^2$                        | N                       | 2N                       | N <sup>2</sup>            | $\frac{n}{2}$         | No (db)                 |
|-------------------------|-----------------------------|---|-------------------------------|---------------------------|---------------------------|------------------------------|------------------------------|-------------------------|--------------------------|---------------------------|-----------------------|-------------------------|
| $20 \log_{10} \epsilon$ | $\theta$                    | $\frac{\theta}{2}$                      | $2\theta$                     | $\epsilon^\theta$         | $\epsilon^{2\theta}$      | $\left(\frac{1}{k}\right)^2$ | $\epsilon^{-2\theta}$        | $(\epsilon^\theta - 1)$ | $2(\epsilon^\theta - 1)$ | $(\epsilon^\theta - 1)^2$ | $\frac{n}{2}$         | $20 \log_{10} \epsilon$ |
| $20 \log_{10} k$        | $\log \frac{k}{\epsilon}$   | $\frac{1}{2} \log \frac{k}{\epsilon}$   | $2 \log \frac{k}{\epsilon}$   | k                         | $k^2$                     | $\left(\frac{1}{k}\right)^2$ | $\left(\frac{1}{k}\right)^2$ | $(k-1)$                 | $2(k-1)$                 | $(k-1)^2$                 | $\frac{n}{2}$         | $20 \log_{10} k$        |
| 29.0                    | 3.3875                      | 1.6937                                  | 6.7750                        | 28.1838                   | 794.3273                  | .0012589                     | .0012589                     | 27.1838                 | 53.3676                  | 738.9699                  | .03679                | 29.0                    |
| 29.5                    | 3.39631                     | 1.69816                                 | 6.79262                       | 29.85384                  | 891.2510                  | .0011220                     | .0011220                     | 28.8538                 | 57.7076                  | 832.5533                  | .03466                | 29.5                    |
| 30.0                    | 3.40388                     | 1.70294                                 | 6.90776                       | 31.62278                  | 1000.000                  | .0010000                     | .0010000                     | 30.6228                 | 61.2456                  | 937.7681                  | .03266                | 30.0                    |
| 31.0                    | 3.56901                     | 1.78450                                 | 7.13802                       | 35.48134                  | 1258.924                  | .00079433                    | .00079433                    | 34.4813                 | 68.9626                  | 1188.939                  | .02900                | 31.0                    |
| 32.0                    | 3.68414                     | 1.84207                                 | 7.36828                       | 39.81072                  | 1584.893                  | .00063096                    | .00063096                    | 38.8107                 | 77.6214                  | 1309.428                  | .02577                | 32.0                    |
| 33.0                    | 3.79927                     | 1.89963                                 | 7.59854                       | 44.66836                  | 1995.262                  | .00050119                    | .00050119                    | 43.6684                 | 87.3368                  | 1906.894                  | .02290                | 33.0                    |
| 34.0                    | 3.91439                     | 1.95720                                 | 7.82878                       | 50.11874                  | 2511.887                  | .00039811                    | .00039811                    | 49.1187                 | 98.2374                  | 2412.676                  | .02036                | 34.0                    |
| 35.0                    | 4.02952                     | 2.01476                                 | 8.05904                       | 56.23416                  | 3162.278                  | .00031623                    | .00031623                    | 55.2342                 | 110.4684                 | 3050.795                  | .01810                | 35.0                    |
| 36.0                    | 4.14465                     | 2.07233                                 | 8.28930                       | 63.09565                  | 3981.072                  | .00025119                    | .00025119                    | 62.0956                 | 124.1912                 | 3855.913                  | .01610                | 36.0                    |
| 37.0                    | 4.25978                     | 2.12989                                 | 8.51956                       | 70.79459                  | 5011.874                  | .00019953                    | .00019953                    | 69.7946                 | 139.5892                 | 4596.162                  | .01433                | 37.0                    |
| 38.0                    | 4.37491                     | 2.18746                                 | 8.74982                       | 79.43273                  | 6309.565                  | .00015850                    | .00015850                    | 78.4327                 | 156.8654                 | 6151.736                  | .01275                | 38.0                    |
| 39.0                    | 4.49004                     | 2.24502                                 | 8.98008                       | 89.12510                  | 7943.273                  | .00012589                    | .00012589                    | 88.1251                 | 176.2502                 | 7766.016                  | .01135                | 39.0                    |
| 40.0                    | 4.60517                     | 2.30258                                 | 9.21034                       | 100.0000                  | 10000.00                  | .00010000                    | .00010000                    | 99.0000                 | 198.0000                 | 9801.000                  | .01010                | 40.0                    |
| 41.0                    | 4.72030                     | 2.36015                                 | 9.44060                       | 112.2018                  | 12589.24                  | .000079433                   | .000079433                   | 111.202                 | 222.404                  | 12365.88                  | .00899                | 41.0                    |
| 42.0                    | 4.83543                     | 2.41771                                 | 9.67086                       | 125.8924                  | 15848.93                  | .000063096                   | .000063096                   | 124.892                 | 249.784                  | 15597.51                  | .00801                | 42.0                    |
| 43.0                    | 4.95056                     | 2.47528                                 | 9.90112                       | 141.2538                  | 19952.62                  | .000050119                   | .000050119                   | 140.254                 | 280.508                  | 19670.06                  | .00713                | 43.0                    |
| 44.0                    | 5.06569                     | 2.53284                                 | 10.13138                      | 158.4893                  | 25118.87                  | .000039811                   | .000039811                   | 157.489                 | 314.978                  | 24803.10                  | .00635                | 44.0                    |
| 45.0                    | 5.18082                     | 2.59041                                 | 10.36164                      | 177.8279                  | 31622.78                  | .000031623                   | .000031623                   | 176.828                 | 353.656                  | 31268.85                  | .00566                | 45.0                    |
| 46.0                    | 5.29595                     | 2.64797                                 | 10.59190                      | 199.5262                  | 39810.72                  | .000025119                   | .000025119                   | 198.526                 | 397.052                  | 39414.16                  | .00504                | 46.0                    |
| 47.0                    | 5.41107                     | 2.70554                                 | 10.82214                      | 223.8722                  | 50118.74                  | .000019953                   | .000019953                   | 222.872                 | 445.744                  | 49671.04                  | .00449                | 47.0                    |
| 48.0                    | 5.52620                     | 2.76310                                 | 11.05240                      | 251.1887                  | 63095.65                  | .000015850                   | .000015850                   | 250.189                 | 500.378                  | 62595.04                  | .00400                | 48.0                    |
| 49.0                    | 5.64133                     | 2.82067                                 | 11.28266                      | 281.8383                  | 79432.73                  | .000012589                   | .000012589                   | 280.838                 | 561.676                  | 78871.11                  | .00356                | 49.0                    |
| 50.0                    | 5.75646                     | 2.87823                                 | 11.51292                      | 316.2278                  | 100000.0                  | .00010000                    | .00010000                    | 315.228                 | 630.456                  | 99369.95                  | .00317                | 50.0                    |
| 51.0                    | 5.87159                     | 2.93580                                 | 11.74318                      | 354.8134                  | 125892.4                  | .000079433                   | .000079433                   | 353.813                 | 707.626                  | 125181.52                 | .00283                | 51.0                    |
| 52.0                    | 5.98672                     | 2.99336                                 | 11.97344                      | 398.1072                  | 158489.3                  | .000063096                   | .000063096                   | 397.107                 | 794.214                  | 157696.35                 | .00252                | 52.0                    |
| 53.0                    | 6.10185                     | 3.05093                                 | 12.20370                      | 446.6836                  | 199526.2                  | .000050119                   | .000050119                   | 445.684                 | 891.368                  | 198630.66                 | .00224                | 53.0                    |
| 54.0                    | 6.21698                     | 3.10849                                 | 12.43396                      | 501.1874                  | 251188.7                  | .000039811                   | .000039811                   | 500.187                 | 1000.37                  | 250190.04                 | .00200                | 54.0                    |
| 55.0                    | 6.33211                     | 3.16605                                 | 12.66422                      | 562.3416                  | 316227.8                  | .000031623                   | .000031623                   | 561.342                 | 1123.68                  | 315102.59                 | .00178                | 55.0                    |
| 56.0                    | 6.44724                     | 3.22362                                 | 12.89448                      | 630.9565                  | 398107.2                  | .000025119                   | .000025119                   | 629.956                 | 1259.91                  | 398499.60                 | .00159                | 56.0                    |
| 57.0                    | 6.56237                     | 3.28118                                 | 13.12474                      | 707.9459                  | 501187.4                  | .000019953                   | .000019953                   | 706.946                 | 1413.89                  | 499778.30                 | .00141                | 57.0                    |
| 58.0                    | 6.67750                     | 3.33875                                 | 13.35500                      | 794.3273                  | 630956.5                  | .000015850                   | .000015850                   | 793.327                 | 1586.65                  | 629372.5                  | .00126                | 58.0                    |
| 59.0                    | 6.79263                     | 3.39631                                 | 13.58526                      | 891.2510                  | 794327.3                  | .000012589                   | .000012589                   | 890.251                 | 1780.50                  | 792545.1                  | .00112                | 59.0                    |
| 60.0                    | 6.90775                     | 3.45388                                 | 13.81550                      | 1000.000                  | 1000000.0                 | .00010000                    | .00010000                    | 999.000                 | 1998.00                  | 998001.0                  | .00100                | 60.0                    |
| 65.0                    | 7.48340                     | 3.74170                                 | 14.96680                      | 1778.279                  | 3.162278x10 <sup>6</sup>  | .00056234                    | .00056234                    | 1777.279                | 3554.56                  | 3.158795x10 <sup>6</sup>  | .00056                | 65.0                    |
| 70.0                    | 8.05905                     | 4.02952                                 | 16.11810                      | 3162.278                  | 10 <sup>7</sup>           | .00031623                    | .00031623                    | 3161.278                | 6322.55                  | 9.999818x10 <sup>6</sup>  | .00032                | 70.0                    |
| 75.0                    | 8.63469                     | 4.31735                                 | 17.26938                      | 5623.416                  | 3.162278x10 <sup>7</sup>  | .00017783                    | .00017783                    | 5622.416                | 11244.8                  | 3.161138x10 <sup>7</sup>  | .00018                | 75.0                    |
| 80.0                    | 9.21034                     | 4.60517                                 | 18.42068                      | 10 <sup>8</sup>           | 10 <sup>8</sup>           | 10 <sup>-8</sup>             | 10 <sup>-8</sup>             | 9999.00                 | 19998.0                  | 9.99980x10 <sup>7</sup>   | 10 <sup>-8</sup>      | 80.0                    |
| 85.0                    | 9.78599                     | 4.89299                                 | 19.57198                      | 1.778278x10 <sup>8</sup>  | 3.162278x10 <sup>8</sup>  | 3.1623x10 <sup>-8</sup>      | 3.1623x10 <sup>-8</sup>      | 1.7782x10 <sup>8</sup>  | 35565.6                  | 3.161995x10 <sup>8</sup>  | 3x10 <sup>-8</sup>    | 85.0                    |
| 90.0                    | 10.3616                     | 5.18082                                 | 20.7232                       | 3.162278x10 <sup>8</sup>  | 10 <sup>9</sup>           | 10 <sup>-9</sup>             | 10 <sup>-9</sup>             | 3.1622x10 <sup>8</sup>  | 63243.6                  | 9.99980x10 <sup>8</sup>   | 1.5x10 <sup>-8</sup>  | 90.0                    |
| 95.0                    | 10.9373                     | 5.46864                                 | 21.8746                       | 5.623416x10 <sup>8</sup>  | 3.162278x10 <sup>9</sup>  | 3.1623x10 <sup>-9</sup>      | 3.1623x10 <sup>-9</sup>      | 5.6234x10 <sup>8</sup>  | 112468.                  | 3.162150x10 <sup>9</sup>  | 2x10 <sup>-9</sup>    | 95.0                    |
| 100.0                   | 11.5130                     | 5.75656                                 | 23.0260                       | 10 <sup>9</sup>           | 10 <sup>9</sup>           | 10 <sup>-9</sup>             | 10 <sup>-9</sup>             | 9.9999x10 <sup>8</sup>  | 199998.                  | 9.99990x10 <sup>9</sup>   | 5x10 <sup>-9</sup>    | 100.0                   |
| 105.0                   | 12.0886                     | 6.0443                                  | 24.1772                       | 1.778278x10 <sup>9</sup>  | 3.162278x10 <sup>10</sup> | 3.1623x10 <sup>-10</sup>     | 3.1623x10 <sup>-10</sup>     | 1.7782x10 <sup>9</sup>  | 355654.                  | 3.16215x10 <sup>10</sup>  | 3x10 <sup>-10</sup>   | 105.0                   |
| 110.0                   | 12.6642                     | 6.3321                                  | 25.3284                       | 3.162278x10 <sup>9</sup>  | 10 <sup>11</sup>          | 10 <sup>-11</sup>            | 10 <sup>-11</sup>            | 3.1622x10 <sup>9</sup>  | 632434.                  | 9.99999x10 <sup>10</sup>  | 1.5x10 <sup>-10</sup> | 110.0                   |
| 115.0                   | 13.2399                     | 6.6199                                  | 26.4798                       | 5.623416x10 <sup>9</sup>  | 3.162278x10 <sup>11</sup> | 3.1623x10 <sup>-11</sup>     | 3.1623x10 <sup>-11</sup>     | 5.6234x10 <sup>9</sup>  | 1.12468x10 <sup>11</sup> | 3.16215x10 <sup>11</sup>  | 10 <sup>-11</sup>     | 115.0                   |
| 120.0                   | 13.8155                     | 6.9078                                  | 27.6310                       | 10 <sup>10</sup>          | 10 <sup>12</sup>          | 10 <sup>-12</sup>            | 10 <sup>-12</sup>            | 9.9999x10 <sup>9</sup>  | 1.99999x10 <sup>10</sup> | 9.99999x10 <sup>11</sup>  | 5x10 <sup>-11</sup>   | 120.0                   |
| 125.0                   | 14.3912                     | 7.1956                                  | 28.7824                       | 1.778278x10 <sup>10</sup> | 3.162278x10 <sup>12</sup> | 3.1623x10 <sup>-12</sup>     | 3.1623x10 <sup>-12</sup>     | 1.7782x10 <sup>10</sup> | 3.55656x10 <sup>12</sup> | 3.16215x10 <sup>12</sup>  | 3x10 <sup>-12</sup>   | 125.0                   |
| 130.0                   | 14.9668                     | 7.4834                                  | 29.9336                       | 3.162278x10 <sup>10</sup> | 10 <sup>13</sup>          | 10 <sup>-13</sup>            | 10 <sup>-13</sup>            | 3.1622x10 <sup>10</sup> | 6.32454x10 <sup>12</sup> | 9.99999x10 <sup>12</sup>  | 3x10 <sup>-12</sup>   | 130.0                   |
| 135.0                   | 15.5425                     | 7.7712                                  | 31.0850                       | 5.623416x10 <sup>10</sup> | 3.162278x10 <sup>13</sup> | 3.1623x10 <sup>-13</sup>     | 3.1623x10 <sup>-13</sup>     | 5.6234x10 <sup>10</sup> | 1.12468x10 <sup>13</sup> | 3.16215x10 <sup>13</sup>  | 1.5x10 <sup>-12</sup> | 135.0                   |
| 140.0                   | 16.1181                     | 8.0590                                  | 32.2362                       | 10 <sup>11</sup>          | 10 <sup>14</sup>          | 10 <sup>-14</sup>            | 10 <sup>-14</sup>            | 9.9999x10 <sup>10</sup> | 1.99999x10 <sup>13</sup> | 9.99999x10 <sup>13</sup>  | 5x10 <sup>-13</sup>   | 140.0                   |
| 150.0                   | 17.2694                     | 8.6347                                  | 34.5388                       | 3.162278x10 <sup>11</sup> | 10 <sup>15</sup>          | 10 <sup>-15</sup>            | 10 <sup>-15</sup>            | 3.1622x10 <sup>11</sup> | 6.32454x10 <sup>13</sup> | 3.16215x10 <sup>14</sup>  | 1.5x10 <sup>-13</sup> | 150.0                   |

$\theta = 0.115129 \times \text{no. of db. } k^2 = \text{ratio of input and output powers of any resistive network. } K > 1. \epsilon = 2.718282, \text{ the mathematical base.}$   
 (Continued on page 70)

# Have you this kind of Faith in your instruments?

If you didn't have faith in your alarm clock you'd spend a restless night. As it is, you sleep soundly because you know that this clock won't fool you—at least not more than once.

But an electrical instrument is different. It doesn't reveal its faithlessness by ringing at the wrong time or by letting you oversleep. It may slowly begin to vary just a little from the truth, and this may not be discovered until great damage has been done.

The only way you can enjoy complete faith in your metering, measuring and testing equipment is to know how it is made. In the case of Boes instruments, we invite this kind of acquaintance. We want you to know how we engineer our instruments, how we earn your faith and confidence by building Boes instruments to meet incredibly stiff standards, how we provide for *sustained accuracy*.\* We believe that an investi-

gation of our facilities, our products, and our methods will reward you with complete confidence in any Boes instrument that you may ever use.

\* **SUSTAINED ACCURACY** is not an easy quality to achieve. It must take into account all factors of use—must then employ the design, the alloys, the construction that infallibly protect an instrument against all threats to its reliable performance. Such instruments, obviously, must be built with performance—not price—in mind. We invite the inquiries of those who are interested in such standards.



# Boes instruments

for Measuring, Metering & Testing Equipment ☆ The W. W. Boes Co., Dayton, Ohio

COMMUNICATIONS FOR AUGUST 1944 • 57

# Specify HOWARD



## WHEN YOU SPECIFY HARNESSSES...

Wiring assemblies individually designed... to your own rigid specifications... by HOWARD, specialists in the design and manufacture of radio equipment.

### HOWARD MANUFACTURING CORP.

★ BUY WAR BONDS ★

COUNCIL BLUFFS, IOWA

Two-Course System—Instrument Landing System," by Charles A. Stanton, CAA Administrator; and "The Army Airways Communication System" by Lieut. Walter W. Fawcett, AAF, an analysis of the system's purpose, operation and equipment, reprinted from a recent issue of COMMUNICATIONS.

This and future issues of the magazine will be sent without charge to airport, airline and municipal officials, and others, upon request.

#### WALKER NOW V-P OF AAC

John B. Walker has been elected vice president in charge of sales of Aircraft Accessory Corporation, Kansas City, Kansas, and will make his headquarters at the company's office at 60 East 42nd Street, New York City. Mr. Walker has been a director of AAC for the past two years. Previous to this, he was associated with United Air Lines, T. W. A., and the Greyhound Bus Lines.



\*\*\*

#### GENERAL RADIO EXPANDS

An additional building housing administrative sales and publicity offices and research laboratories, has been opened by General Radio Company at 275 Massachusetts Avenue, Cambridge 39, Massachusetts.

\*\*\*

#### WESTINGHOUSE AWARD TO R. E. STOWE

Richard E. Stowe, manager of the Dayton office of Westinghouse Electric & Manufacturing Company, was awarded the company's highest honor recently, the "Order of Merit" Mr. Stowe, with Westinghouse for seventeen years, was cited for his distinguished service in the application of electricity to aircraft.

\*\*\*

#### HALLICRAFTERS DONATES \$5,000 TO ARMY HOSPITAL

A total of \$5,000 was presented recently by management and employees of the Hallicrafters Company, Chicago, to the Army's new Vaughn General Hospital at Hines, Illinois. The donation represents overtime earnings of employees on D-Day, and the company's fund set aside for the workers' annual picnic which they voted cancelled this year.

\*\*\*

#### PHILIP F. SILING OF FCC JOINS RCA

Philip F. Siling, assistant chief engineer in charge of broadcasting, Federal Communications Commission, Washington, D. C., has been appointed engineer-in-charge of the frequency bureau of the Radio Corporation of America effective October 1.

In his new post, Mr. Siling, who has been associated with the FCC for nine years, will handle matters pertaining to frequency allocations and licenses for RCA, its subsidiaries and services.

Mr. Siling will maintain offices in the RCA Building, 30 Rockefeller Plaza, New York, at 1625 K Street, N. W., Washington, D. C. The duties of the engineer-in-charge of the RCA Frequency Bureau have been administered by Dr. B. E. Shackelford since the post was relinquished two years ago by Dr. C. B. Jaffe, former chief engineer of the FCC, who became chief engineer of the RCA Victor Division, Camden, N. J. Dr. Shackelford will retain general direction of the Bureau's activities. C. E. Pfautz is manager of the New York office of the Bureau.

\*\*\*

#### REX MUNGER RETURNS TO TAYLOR TUBES

Rex L. Munger has returned to his old post with Taylor Tubes, Inc., 2312 Wabansia Avenue (Continued on page 78)

## NEWS BRIEFS OF THE MONTH...

### NBC TELEVISION COURSE FOR AFFILIATED STATION ENGINEERS

A special four-week course in television for the engineering personnel of its affiliated stations is being sponsored by the National Broadcasting Company. Beginning October 2nd, the faculty of the RCA Institutes and executives and network engineers of NBC will conduct a series of twenty sessions on the major elements of the television system, including the theory of component units such as the design and operation of electronic tubes, control circuits, and wide-band amplifiers.

Commercial engineering and economic considerations of television will be discussed by William S. Hedges, NBC vice president in charge of stations, O. B. Hanson, NBC vice president and chief engineer, and Philip I. Merryman, NBC director of facilities development and research. Among others of NBC's engineering staff who will take part in the lectures and field trips are Robert E. Shelby, George M. Nixon, Raymond F. Guy, Albert W. Protzman, Fred A. Wankel, Thomas J. Buzalski, John L. Siebert, Harold See and A. L. Hammerschmidt.

### "E" AWARDS

The continued maintenance of high production standards by the radio industry has been evidenced by the number of Army-Navy "E" flags and white stars awarded manufacturers during the past months. Three recent winners of "E" flags included Universal Microphone Company of Inglewood, California, Electro-Voice Manufacturing Company, Inc., of South Bend, Indiana, and Aerovox Corporation, New Bedford and Taunton, Mass.

Electronic Enterprises, Inc., of 67 Seventh Avenue, Newark, New Jersey, received a white star for its "E" flag recently. Second white star awards were presented to General Electric Company's Bridgeport plant, and the Sumner-Tubing Company of Bridgeport. Four other companies received their third white stars:

Philco Corporation of Philadelphia, Sheffield Corporation of Dayton, Ohio, the Hallicrafters Company of Chicago, and the four divisions of Raytheon Manufacturing Company of Newton and Waltham, Massachusetts.



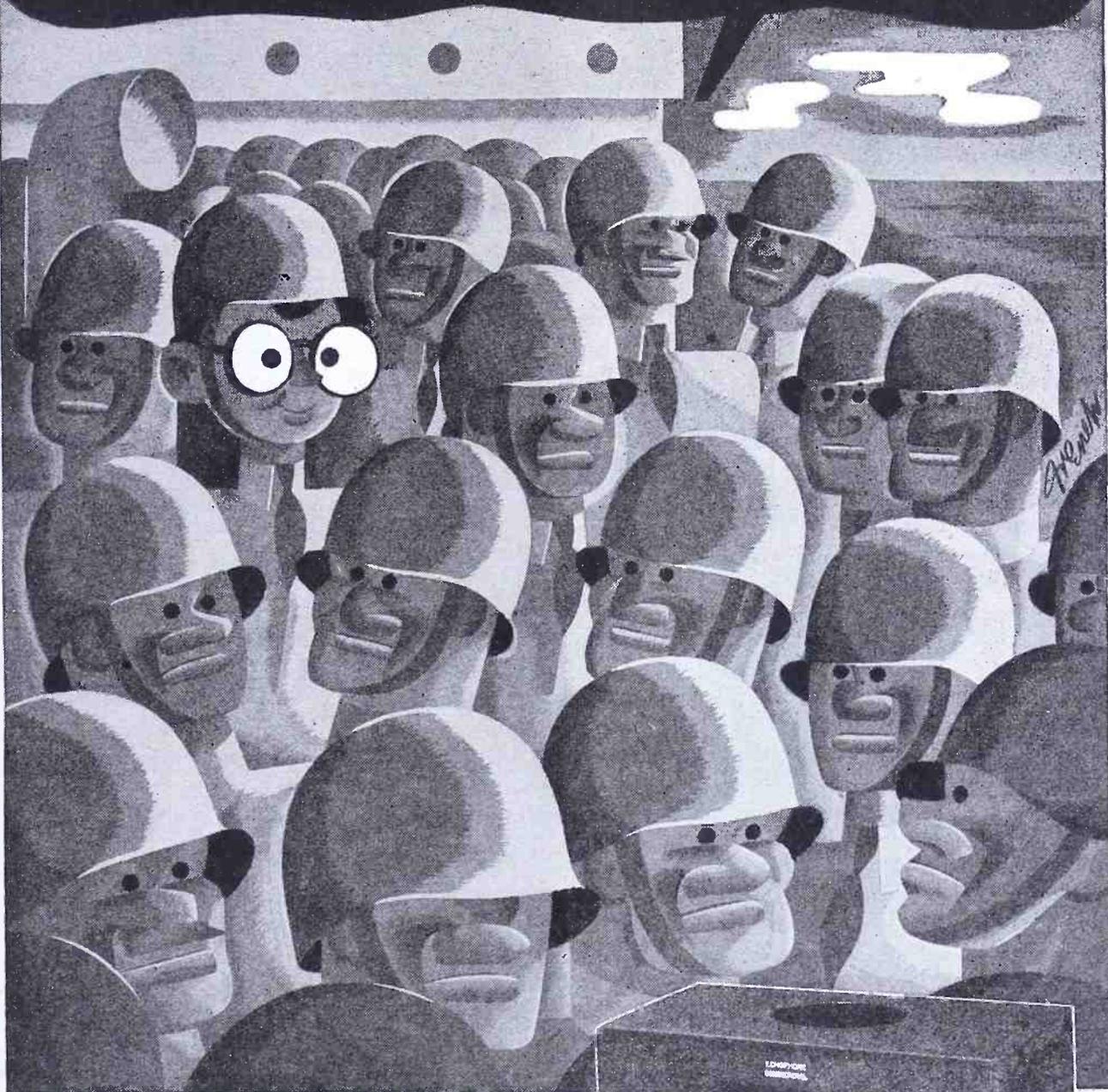
At Universal Microphone "E" award, left to right: Col. S. W. Stanley, chief Signal Branch, Forward Echelon, 9th Service Command, who presented award; James L. Fouch, U. M. president; Commander Edwin F. Keyes, USNR, assistant inspector of naval materials, Los Angeles district, who presented citation.

### RADIO AVIATION BOOKLET ISSUED BY RADIO RECEPTOR

The first issue of "Highways of the Air," devoted to promotion of radio in aviation, has been released by Radio Receptor Company, Inc., 251 West 19 Street, New York 11, New York.

Four articles on aeronautical radio appear in this initial issue, including a fifth reprint of a booklet originally published by the company in 1935 outlining radio navigation aids. The papers presented are: "Airway and Ground Facilities of the Future" by William A. M. Burden, Assistant Secretary of Commerce; "Radio in Aviation—CAA's U-H-F Range Program—The

HOGARTH DOESN'T MIND—HE'S USED TO HAVING  
A CROWD AROUND HIS **ECHOPHONE EC-1**



### **ECHOPHONE MODEL EC-1**

(Illustrated) a compact communications receiver with every necessary feature for good reception. Covers from 550 kc. to 30 mc. on 3 bands. Electrical bandspread on all bands. Six tubes. Self-contained speaker. 115-125 volts AC or DC.



**ECHOPHONE RADIO CO., 540 NORTH MICHIGAN AVE., CHICAGO 11, ILLINOIS**



W. J. McGONIGLE, President

RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y.

GEORGE H. CLARK, Secretary

Personals

**A** RETIRED Chief Radioman of the United States Navy, more recently a supervisor in the broadcast program department of the American Telephone and Telegraph Company, is back in the front lines as a USN Chief Radioman. We are referring to Fred McDermott, CRM USN, who wishes to be remembered to all the boys and requests them to *keep the home fires burning*. Fred's address is Navy 1925 C/O Fleet P. O. New York, N. Y. . . . Willard S. Wilson, our resident agent in Delaware, is now Major Wilson, Communications Officer of the Tenth Air Force in India. Good luck, Willard! . . . Jack Poppele states that Robert Cooper of Cincinnati desires information on membership in our Association. . . . We are reserving a Year Book for Harold D. Kaulback of the Bureau of Ships, Navy Department, Washington, D. C. . . . Glad to see Jim Maresca, one of our first Association secretaries, at our recent dinner-cruise in New York. Jim is back in the Signal Corps down Jersey way. He was in there pitching in the last war, too. . . . An interesting letter has come in from T/SGT Preston L. Stocum, now an instructor at the Signal Corps School at Camp Crowder, Mo. . . . Glad to welcome R. J. Iverson of the *New York Times* staff back into our activities again. . . . "Bill" Simon, treasurer and executive secretary, gratefully acknowledges the splendid cooperation of the majority of our membership in bringing their dues up to date. Did you? . . . We noted with interest that a memorial, honoring the graduates of the Maritime Service Radio Training Station at Gallups Island who lost their lives in the service of their country, was dedicated at the station recently. Commander Sherman W. Reed, the superintendent, paid tribute to the bravery of the nineteen men. . . . "Bill" Beakes, VWOA life member, continues to enjoy the splendid Florida weather. . . . Jack Poppele, chief engineer of WOR, was recently appointed consulting radio engineer to the New Jersey State Police. . . . From Captain P. H. Boucheron, USNR, we've



The late William A. Winterbottom, life member of VWOA, who was awarded posthumously, the Signal Corps Certificate of Appreciation for his services to the U. S. Army Signal Corps.

received a letter, saying in part: "Sorry couldn't be there on the 27th of April since I just received your note and it is a little too far—9,000 miles from New York. Regards and best wishes to all." . . . Harold Ellis, formerly of the Tropical organization, is now stationed at the Mare Island Navy Yard. . . . Our sincere sympathies to member Wm. W. Pearson on the recent loss of his wife. . . . Looking back, Tom Stevens, life member, notes: "It looks as though all the old ships on which I served as *Sparks* are doomed. The Merida lies deep off Hatteras, the Harvard was wrecked out here on the Pacific Coast, and now the City of Atlanta has been sunk." . . . Martell E. Montgomery, one of our oldtimers, is now chief communications engineer, Reconstruction Finance Corporation, Deteuss Supplies Corp., American Republics Aviation, with headquarters at Rio de Janiero, Brazil. He received his first class operator's license in 1922, and has held on to it ever since. . . . Peter Podell, one of VWOA's best friends, is now an FCC Intercept Officer of New York. "Pete" began his radio career in 1913 as radio operator for the Marconi Wireless Telephone Company. In World War I he served as chief radio man in the United States Navy. Two of his boys are now in the Armed Forces, one being a sergeant in the Signal Corps, and another a technical sergeant in the Ordnance Department. . . . Edward J. Content,

veteran VWOA man, and in radio since 1917, was with the Rainbow Division of the Army and later was in the Coast Guard. . . . Oliver W. Penney, master control operator of WMCA, entered radio to avoid a dental career, *and it took*. . . . Jim Maresca, a charter member, is now with the Signal Corps at Belmar N. J., with 33 years of radio and sound. He was also in the Signal Corps during World War I. . . . E. D. Van Duyne, in radio since 1919 when he started with A. H. Grebe, is now with RCA as a field engineer. . . . "Bill" Simon, our treasurer, was mustered out of the Marine Corps in 1920 as a Technical Sergeant and has been with Tropical Radio these many years. . . . Dick Sanford, a former wireless operator, is now a songwriter and member of American Society of Composers and Publishers.

In Memoriam

**W**ILLIAM A. WINTERBOTTOM, old-time wire and cable operator, and vice president and general manager of RCA Communications, Inc., died recently. Only a month before his death, he had celebrated his thirtieth anniversary of association with the radio communications industry. He joined the Marconi Wireless Telegraph Company of America on June 1, 1914.

He was an active life member of the Veterans Wireless Operators Association. He always saw to it that his company was represented in every way in the Association's activities whether it be on the pages of the *Year Book*, or at the gatherings of old-timers from year to year.

The Signal Corps awarded him posthumously the Certificate of Appreciation, for his "services of immense value" to the United States Army Signal Corps.

The presentation was made at the RCAC offices, 66 Broad Street, by Col. Jay D. B. Lattin, Signal Officer of the Second Service Command, to Mr. Winterbottom's son, Arthur W. Winterbottom, manager of the Plan Valuation Division of RCA Communications.

Truly, indeed, we mourn his loss.

# WHERE TOMORROW MEETS TODAY

Up there  
above the clouds  
the Dreams of Tomorrow  
are being proven  
today



**S**OARING COMBAT PLANES sing a song of the future! In equipment and efficiency they far outstrip normal peace-time ambitions. They are born of the grim challenge of war for new and ever-improved electrical design.

Vision and inventive genius are required to originate such new developments, and in this field Small Electric Motors (Canada) Limited have been privileged to make important scientific contributions. Out of the experience gained today by forward-looking firms like this, substantial benefits will accrue to the world of tomorrow.

At the moment, Small Electric Motors is in full production for Victory but in the post-war field of electrical equipment the influence of this aggregation of creative engineering minds will also be recognized for specialized services of a high order.

**DESIGNERS  
AND MANUFACTURERS  
Of All Types of Precision  
Electrical Apparatus  
Including:**

*D.C. & A.C. Motors for  
Specialized Purposes  
Aircraft Generators  
Aircraft Engine Starters  
Alternators  
Motor Generators  
Electric Pumps  
Motors with Governors  
Gyros, etc.*

**SMALL**  **Electric Motors**  
(CANADA) LIMITED

E A S I D E • T O R O N T O • C A N A D A

COMMUNICATIONS FOR AUGUST 1944 • 61

# PORTABLE POWER PROBLEMS

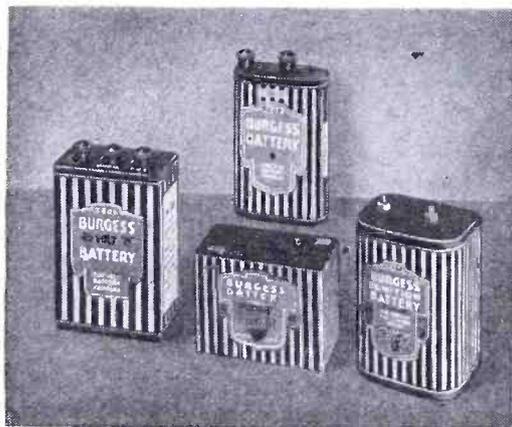
## No. 4—Veneer Drying Control



Photo — Pluswood, Inc.

### FAMOUS ALL-WOOD "MOSQUITO" of the Royal Air Force is

of tough, durable wood veneer — made to a rigid engineering specification. The physical characteristics of this veneer must be as uniform as metal. Most vital step in production is the drying where precision control of moisture content assures its stability and strong cell structure . . . guarded by electronic moisture-meters powered by Burgess batteries.



**SPECIAL-PURPOSE BATTERIES** have always been a specialty of Burgess engineers. Puzzling problems of size and operating characteristics dissolve in their expert hands . . . your problem will be welcomed.

### FREE..ENGINEERING HANDBOOK

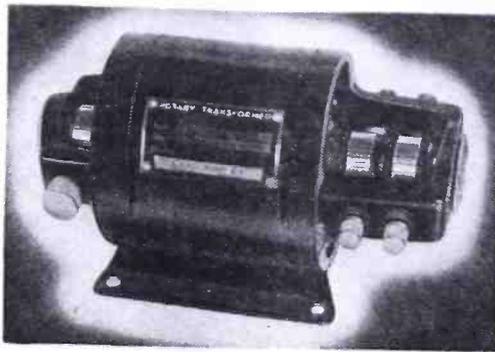
80-page manual of basic data and characteristics of dry batteries for all electronic applications. Tabbed for ready reference. Write Dept. 6 for free copy. Burgess Battery Company, Freeport, Illinois.

## BURGESS BATTERIES

# THE INDUSTRY OFFERS...

### CARTER MULTI-OUTPUT DYNAMOTORS

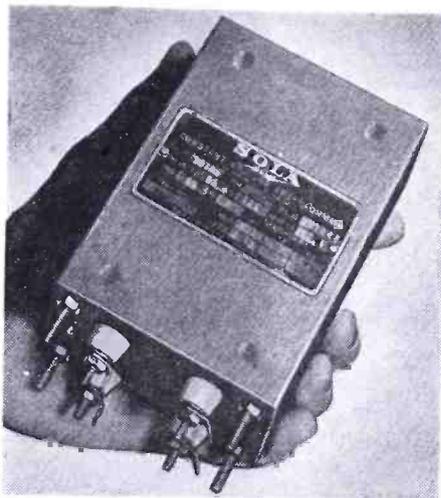
A multi-output dynamotor has been developed by the Carter Motor Company, 1608 Milwaukee Avenue, Chicago.



### SOLA CONSTANT VOLTAGE TRANSFORMER

A hermetically sealed constant voltage transformer for chassis mounting, has been announced by Sola Electric Company, 2525 Clybourn Ave., Chicago 14, Ill.

Rated at 6.3 volts, 17 va output, manufacturer says that unit will maintain value within  $\pm 1\%$  regardless of line voltage variations as great as  $\pm 12$  to 15%.



### CURTIS FEED-THRU TERMINALS

Feed-thru terminal blocks consisting of individual feed-thru terminals, molded in bakelite, permanently held in a metal strip and having any number of units between 1 and 16, have been announced by Curtis Development and Manufacturing Company, 1 No. Crawford Avenue, Chicago, Illinois. Factory is in Milwaukee, Wisconsin.

Terminals are said to have ample clearances and leakage distances for circuits carrying up to 300 volts, 20 amperes. Center-to-center distance between terminal units is  $\frac{5}{8}$ ". No. 8 screws are used on each side of terminal units for securing connection. The two mounting holes at each end of the terminal base take No. 8 machine screws.

Blocks with any terminals needed can also be supplied.

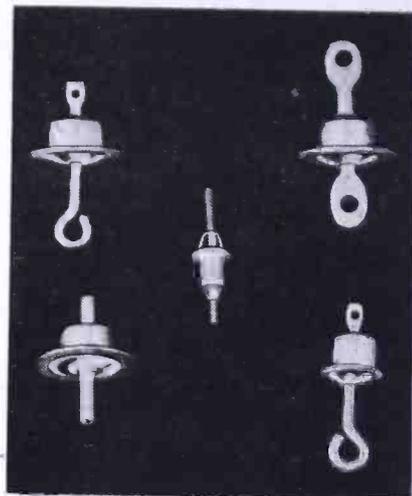


### E. I. SEALED LEADS

Hermetically sealed leads constructed of pyrex glass with Kovar electrodes and Kovar metal collars have been announced by Electrical Industries, Inc., 42 Summer Ave., Newark 4, N. J. The pyrex glass is said to assure high dielectric strength, immunity to any reasonable thermal or mechanical shock as well as freedom from absorption of moisture and humidity. The surface of the glass insulator is such as to provide maximum water shedding properties.

The pyrex glass and Kovar metal are said

to form an absolutely gas and moisture tight to form gas and moisture tight chemical bond, so that internal gas pressure may be maintained in units employing these leads.



### ANDREW COAXIAL PLUGS AND JACKS

Coaxial plugs and jacks with built-in sliding sections, to simplify disassembling and soldering have been produced by Andrew Co., Chicago, Ill.

Plugs and jacks are machined from bar brass stock. Inner conductor contacts are silver plated to give maximum conductivity. Insulation is Mycalex.



### JENNINGS VACUUM CONDENSERS

Vacuum type condensers with capacity ranges of 50, 75, 100, 150, 200, and 250 mmfd, are now available from Jennings Radio Mfg. Co., San Jose, California. Known as the VC-50 and VC-250 types, the condensers have a maximum voltage peak of 20,000; maximum current, peak, 60 amperes. Frequency range is said to be 60 cycles to u-h-f. Has a ferrule type mounting. Other features include zero power factor, no cold emission, and plug-in bases.

### NATIONAL INSTRUMENT TIMER

An electrically operated counter to automatically register the total number of hours that an electrical device or motor driven machine has been in operation is now available from National Instrument Co., 246 Walnut St., Newtonville, Mass.

A small slow-speed self-starting synchronous motor drives a set of numbered wheels through a gear train.

Size: 3 9/16" x 3 1/4" x 2 1/8". Registration of 99,999.9 hours, maximum is said to be possible. Right hand figure reads tenths of hours. Can be supplied to read minutes and tenths.

For 100-125 volts, 60 cycles, 2 watts; other voltages and frequencies can also be supplied.

Can be also supplied with a relay for special applications, such as measurements of direct current devices, flow of gases or liquids in pipes, motions, e. g., conveyor belts.

### PRECISION PAPER TUBE COMPANY MANDRELS

Approximately 750 mandrels, small to large, for the forming of round, square, and rectangular dielectric paper tubes, as coil bases, are included in a new list just issued by Precision Paper Tube Company, 2023 West Charleston St., Chicago 47, Illinois.

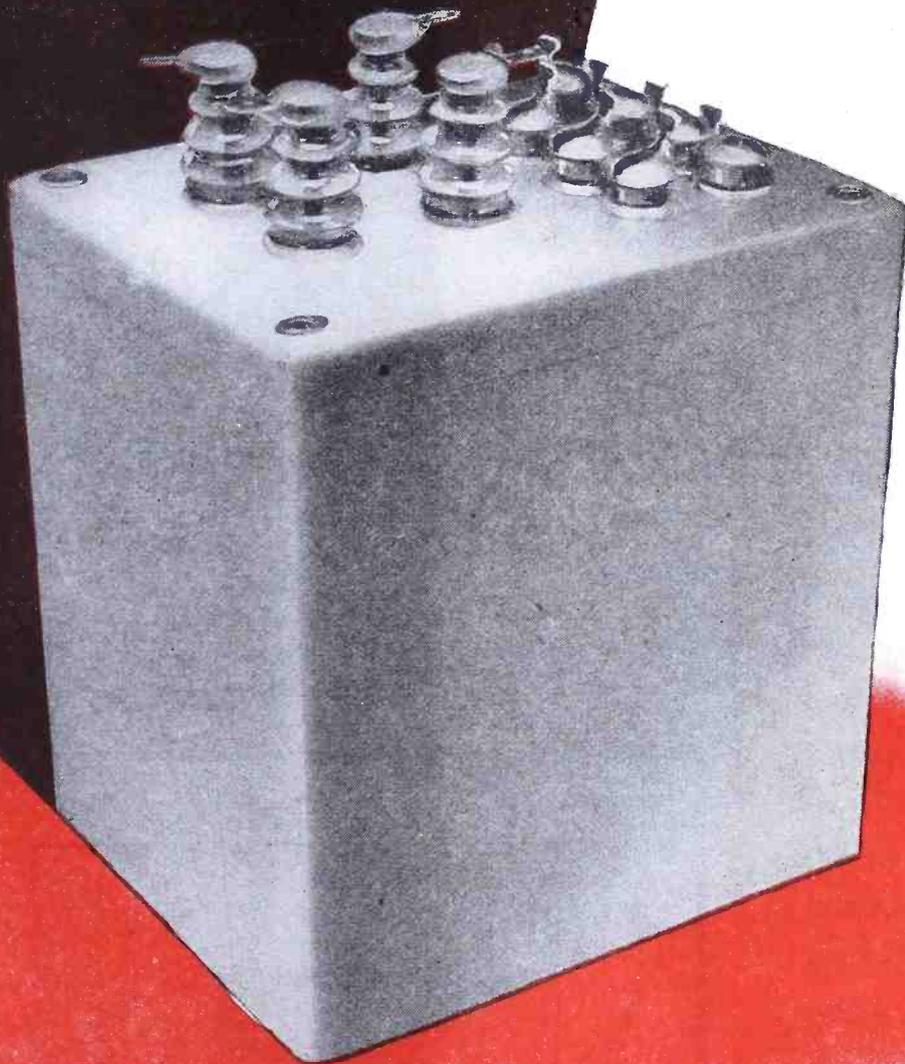
This new list of mandrels provides for practically all sizes and shapes, any length, any i-d or o-d, of tubes made to specifications, of dielectric kraft, fish paper, cellulose acetate, or combinations.

### FIBRON PLASTIC TAPE

A vinylite plastic tape, "Fibron," has been announced by Irvington Varnish & Insulator Company, Irvington 11, N. J. It is used for insulating wires, cables and electrical equipment; for splicing cables; and for protecting wiring, piping, and equipment exposed to caustic

(Continued on page 84)

**POWER SUPPLY  
COMPONENTS  
FOR WAR**



The complex power supplies of war apparatus require components of maximum dependability. The unit illustrated is a typical power transformer for cathode ray application. In addition to the tapped primary, this unit provides a low voltage filament winding . . . a 5,000 volt anode supply winding . . . and a filament winding insulated for 15,000 volts peak inverse.

For hermetic sealing this unit employs an all metal enclosure . . . glass seal terminals . . . sealing compound which neither cracks nor flows from  $-55^{\circ}\text{C}$  to  $+130^{\circ}\text{C}$ .

*May we cooperate with you on design savings for your applications...war or postwar?*

*United Transformer Co.*

150 VARICK STREET

NEW YORK 13, N. Y.

EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y., CABLES: "ARLAB"

More  
Efficient



Take the limited frequency range of the average single unit speaker... increase it to 15,000 cycles plus... extend and smooth the bass response... and you have the more efficient method of sound reproduction delivered by the Altec Lansing multi-cellular Duplex speaker. It's a small, compact two-way speaker with a 60° angle of horizontal distribution... which for the first time in history, revolutionizes the methods of sound reproduction.

SEND FOR BULLETINS

**ALTEC**  
LANSING CORPORATION

1210 TAFT BLDG., HOLLYWOOD 28, CALIF.

# PRE-FLIGHT COMPASS TESTS

(Continued from page 35)

tenna of 50-mmfd capacity and 0.25-meter effective height. This condition cannot be readily determined by measurements on the test set-up on the aircraft as referred to in Figures 1 and 2. The oscillator output and sense voltage value can be readily adjusted to the optimum value by using available circuit functions and a dynamometer type meter. The particular type referred to is that which is generally used with the left-right type radio compass. The *l/r* indicator is connected in the automatic compass circuit in place of the loop director circuit, i. e., in place of the thyatron circuit. This can be easily accomplished in an installation where the circuits are designed in separate units and the interconnection cables can be intercepted at the terminal junction box. The circuits may also be intercepted by use of adaptor cable plugs. More specifically the temporary test hook-up consists essentially of connecting one of the two *l/r* meter coils to the 48 cps source and the other coil to the output of the compass amplifier tube. Based upon the aforementioned field strength, the *l/r* meter will give full scale deflection for 6° rotation (within 1°) of the loop antenna from the homing position, i. e., rotation of the loop antenna from 0° (homing) to 6° or 7° for a full left meter deflection and likewise for a full right meter de-

flection. During this calibration test we must make sure that the aircraft supply voltage input is of normal value. Low battery voltage will give erroneous readings. (Receiver sensitivity varies with input primary power and is apt to occur when external battery is used. During flight the dual generators and voltage regulators maintain a constant supply.) For example, with all other factors being correct, a drop in battery voltage of 12 to 9 volts will result in a 6° to a 37° rotation of the loop antenna to give full deflection of the *l/r* indicator. For reference, a curve expressing quantitative values for a specific condition is given in Figure 5. (Normal operating voltage is 14, however for ground test a 6-cell battery is used hence the reference to 12 volts.)

This method of calibration was arrived at by making a series of tests on a comparison basis with the model of the test oscillator on the aircraft, to the equivalent test made in the radio compass screen room in conjunction with the *l/r* meter. A field-strength value determined in the screen room can be duplicated on the aircraft with the required degree of accuracy for the overall compass installation check. The important factor here is that for a specified  $\mu\text{v}/\text{m}$ , the full scale *l/r*

(Continued on page 66)

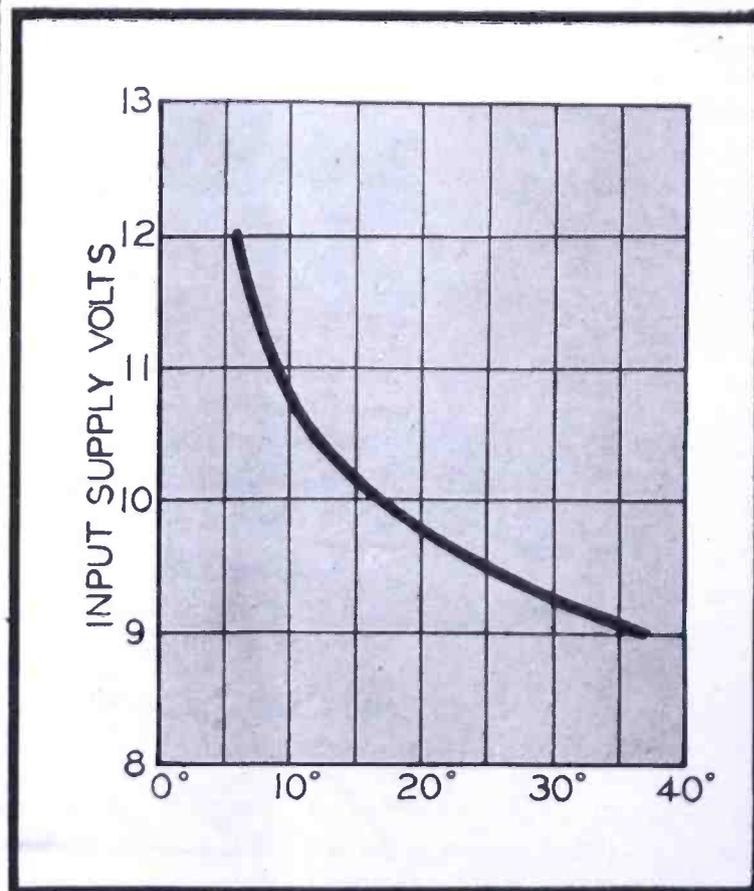


Figure 5  
For one specific test condition, the degree rotation of the loop antenna (1000  $\mu\text{v}/\text{m}$ ) to give full scale *l/r* indicator deflection as a function of input supply volts to the compass equipment. Test voltage reference is usually 12. The equipment is designed for operation on a normal supply of 14 volts, which is the voltage delivered when aircraft generators are operating.

# IRC WILL BE READY

## with TYPE BW INSULATED WIRE WOUND RESISTORS



At the first indication of lessened demand by the Armed Services, IRC will be in an excellent position to immediately supply industry's requirements for resistors of *all* types. That IRC units will be available in ample quantities on a favorable price basis is assured because we have developed and are operating on a mass production basis the world's largest resistor plants.

### RESISTOR PROBLEMS WELCOME

Feel free at all times to consult with us on your peacetime product design plans involving resistances. You can be certain of unbiased engineering counsel and secure in the knowledge that the subject matter will be held inviolate.



### CHECK THESE FEATURES OF TYPE BW WIRE WOUND RESISTORS

1. Completely insulated wire wound of standard  $\frac{1}{2}$ , 1 and 2 watt sizes.
2. Resistance values:  $\frac{1}{2}$  watt—from .24 ohms to 800 ohms; 1 watt—from .5 ohms to 5000 ohms; 2 watt—from 1.0 ohms to 8000 ohms.
3. Have wire wound stability and are physically interchangeable with carbon types.
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### PRE-FLIGHT TESTS

(Continued from page 64)

meter deflection is a function of loop antenna angular displacement from  $0^\circ$  (homing position). It is evident that use of the  $l/r$  meter as a medium of calibration-oscillator output, for a given  $\mu\text{v}/\text{m}$  when made on the plane, will take in account the actual loss factors existing in the aircraft test *set-up* without the necessity of actually measuring them; in Figure 2, for instance, the r-f loss in the beacon antenna leadin.

Known and controlled values within

required limits of the loop antenna field strength as well as sense-antenna effective height are available in a screen room *set-up*. Briefly, the screen room *set-up* comprises a transmission line located directly above the center of the loop antenna. One end of the line is connected to a signal generator. The other end of the line is terminated to the shield of the room through a resistor equal to the characteristic impedance of the transmission line. For a given set of conditions, including distance of loop antenna center to the transmission line, and the distance of the line from the top shield and bot-

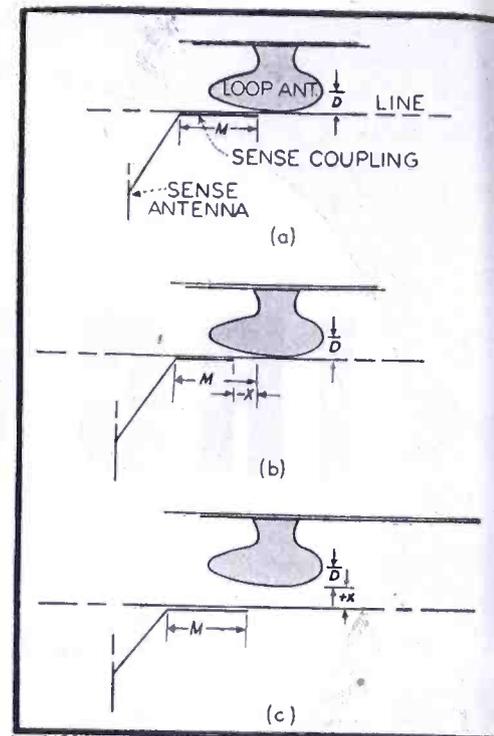


Figure 6

The  $l/r$  meter deflection for a given field strength is a function of the loop antenna to sense antenna voltage ratio, i. e., same deflection may be obtained for two entirely different field strength values by juggling of height of sense antenna or coupling from the line to the loop antenna. Condition (a): A selected value of overall receiver gain must be maintained, as well as a standard reference spacing of the loop antenna center to the line. Condition (b): The carrier amplitude is decreased when sense coupling is decreased. Thus the percentage of modulation is increased. Therefore, the angular change of loop antenna position is less for a given  $l/r$  meter deflection. Condition (c): As the distance between the loop antenna and the line is increased, the loop coupling voltage is decreased. The result is a reduction of 48 cps side band amplitude. Therefore, the percentage of modulation is decreased and a greater angular loop antenna displacement is required for a given  $l/r$  meter deflection.

tom shield of the screen room, the  $\mu\text{v}/\text{m}$  field strength can be determined by a constant multiple of the signal generator attenuator scale reading. This condition would be very difficult to duplicate on the aircraft and for that reason it is better to work from a comparison basis. The  $l/r$  meter was found to be an ideal tool to do the job.

The  $l/r$  test instrument in complete form is shown on pages 33 and 68. Designed especially for use with the Bendix MN31 radio compass, it is only necessary that the MN31 loop-director cable plug be connected to the adaptor cable plug assembly. Mounted on the panel are the  $l/r$  meter, supply line input meter, a selector switch for automatic radio compass or  $l/r$  meter, operation and a loop antenna rotator switch. The latter permits remote rotation control of the loop antenna at desired rate of speed and direction. (The  $l/r$  indicator circuit presented here is not to be considered as an adoption of a  $l/r$  compass for navigational purposes.)

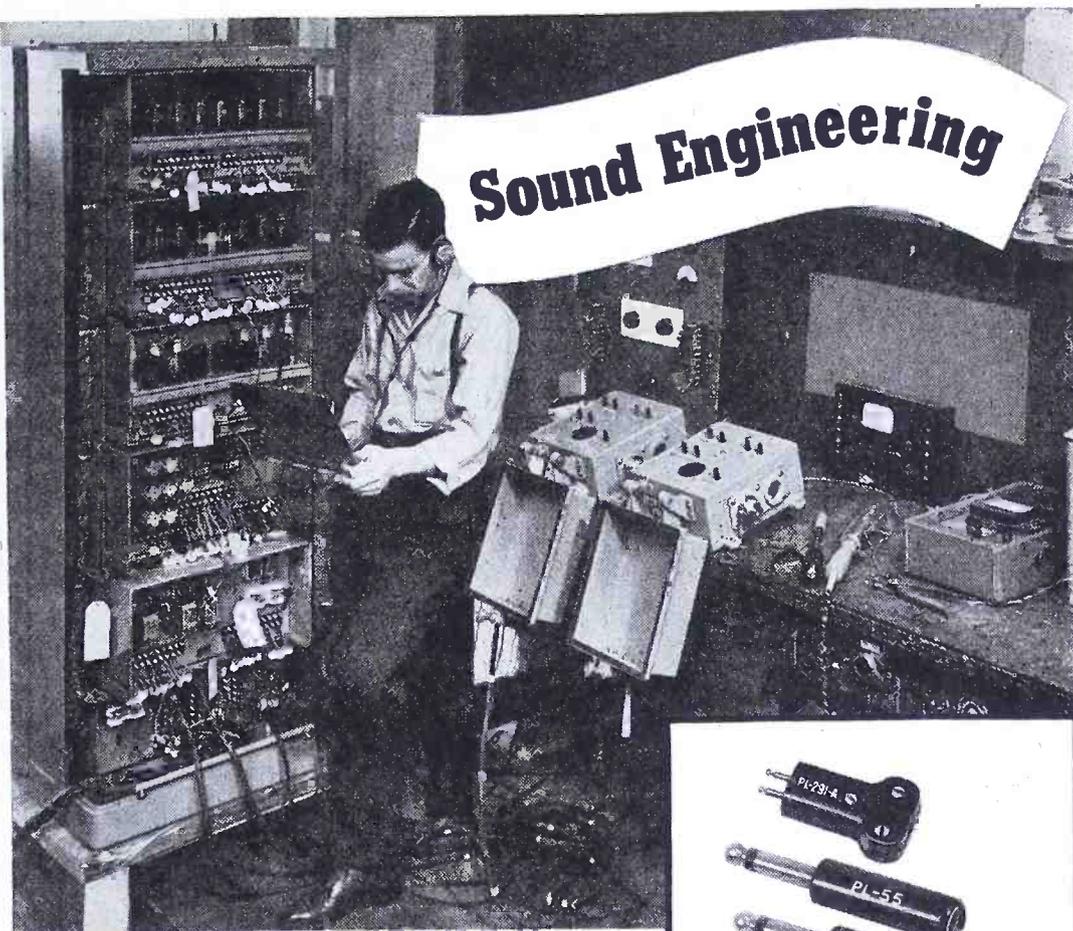
In the  $l/r$  indicator, when loop antenna is in the null position, the meter

indicating needle is centered. When the loop antenna is rotated to one side of the null, the meter is deflected from center in one direction and a reversed deflection occurs when the loop antenna is rotated in the opposite direction from the null. This means that the meter is *sensed* so that the center position of the dial represents the airplane nose. A left meter deflection indicates that the signal direction is approaching from the forward left of the plane of the loop antenna, and a right deflection indicates when the signal direction is from the forward right of the plane of the loop antenna. A signal arriving at the back side of the loop antenna (other than null) will give a reverse indication. From this we can see that with a meter deflection opposite to the direction of loop antenna rotation the source of signal is from a forward point. Conversely a meter deflection that follows the same direction of the loop antenna rotation indicates that the signal source is to the rear. This is based on reference to the azimuth reading as to the front of the loop antenna. This is not to be confused with the old *standard* used prior to 1939 which is now obsolete. The present standard was adapted to conform with the aeronautical flight instrument standards. These are . . . "to fly into the indication" for the correction. For example, when the airplane heading is 30° and directly toward the radio transmitter, the *l/r* needle is at center point of the scale. If the airplane heading is altered to 45° (15 degrees to right of the station) then the *l/r* indicator gives a left deflection. The signal source is to the forward left of the plane of the loop antenna. For a correction, to again fly a heading toward the station, the heading is altered to the left . . . "fly into the indication, to enter the meter."

The *l/r* test instrument is quite versatile, in that it can be used to isolate a loop antenna, antenna relay, separate loop antenna transmission line double from loop director or autosyn double, when symptoms of incorrect response are given.

The fixed coils in the circuit, Figure 4 (terminals 1, 3, 5 of the dynamometer type *l/r* indicating meter), are resonated at 48 cps. When connected in the circuit by SW<sub>1</sub> it becomes the oscillator tuned circuit of the transmitter and replaces the tuned circuit of T<sub>6</sub>. The latter is in operation when the automatic compass is used. The compass amplifier output is connected to the moving coil (terminals 2-4). This

(Continued on page 68)



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| 58      | 65 | 108 | 125 | 354   |
| 59      | 67 | 109 | 127 |       |
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|-----|-----|-----|-----|-----|-----|
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| 59  | 67  | 59  | 67  | 59  | 65  |
| 60  | 74  | 60  | 74  | 60  | 74  |
| 61  | 76  | 61  | 76  | 61  | 76  |
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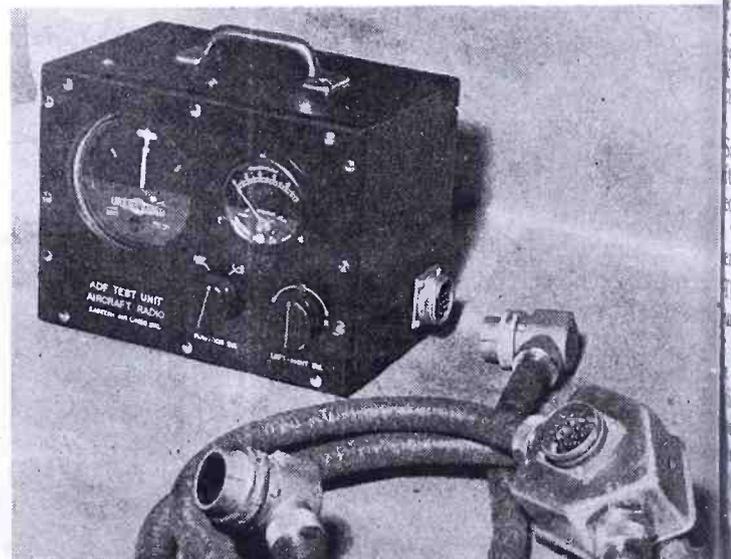
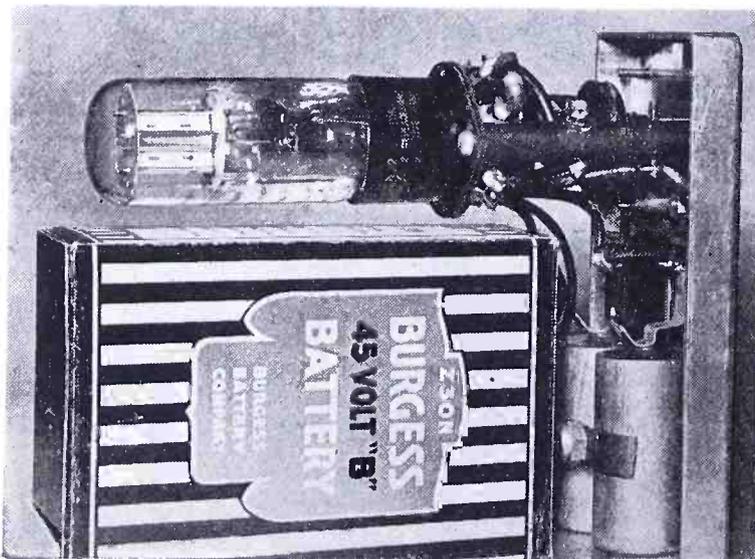
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supplies the 48 cps modulated signal. For a loop antenna position at other than a null, the moving coil 48 cps phase relation to the fixed coil, determines the direction of deflection of meter. With the loop antenna at null position the moving coil does not receive a 48-cps modulated signal voltage and the *l/r* indicator is centered.

For reason of safety, it is necessary to provide a departure check of aircraft's radio compass when plane is in the clear on the engine run-up ramp. During this check the accuracy of the radio compass is observed by taking bearings on two or more stations. This is done by setting the azimuth dial index to the magnetic compass heading. The bearing accuracy is determined by comparing it with the known bearing from run-up ramp being used, to the radio station to which the receiver is tuned. The engine run-up test is made shortly before the trip departure time. To avoid a plane departure delay, it is obviously an advantage to determine whether a radio compass installation defect exists long before the plane is scheduled to be towed to the run-up ramp. This requirement prompted the development of this radio compass test oscillator device. At any convenient time during the service period, regardless of whether the plane is in hangar or not otherwise in the clear of metal objects, the test oscillator used in conjunction with the transmission line will permit a radio compass overall installation test. It

At left, below, internal view of the oscillator unit. Battery power supply is held in place by clips and these clips on the parallel *A* battery also serve to make circuit connections. Below, *l/r* test instrument interconnecting cable. On the panel of the *l/r* meter, and the input line meter. The controls are *sw1* two-position function switch and the *l/r* loop antenna rotator control. Cable plug adjacent to unit plug is programmed in Figure 4 as P1; P3 is the foreground plug, and the P2 plug is mounted on conduit box.



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e influenced by external effects. equipment deficiencies and the ing can readily be determined his device: (1)—correct sense ng of compass component; (2)— ul indicator needle hunt; (3)— l performance and in particular ll seeking ability of the compass; check for correct sense and loop a cable connections; and (5)— t autosyn indication.

h reference to the latter, it has found that a spinning needle is o an autosyn rotor slip ring having intermittent contact. A ve angle indication is usually d by reversed phase stator wind- onnections; an indication over arc, only, is most likely due to an stator phase winding. A normal ying indication of the autosyn in- or with abrupt 180° ambiguity be due to open rotor circuit. It previously mentioned that some e above referred-to symptoms will hibited solely because of the near- of metal objects or ground wires. efore the trouble should be double ed to make certain that it is not d by a source external to the in- tion.

e approved type aircraft radio ass, even though it is in the class omplicated apparatus has proved e remarkably free from defects. ever, the need for a thorough per- ance test is apparent since it is a gnized fact that the compass, as any type of equipment, is subject alfunctioning because of operating itions encountered. These condi- may be extreme variations of erature and pressure as well as ation and humidity which con- te to deterioration of components.

## ography

ebb and Essex, *Automatic Radio Compass*, nautical Engineering Review, Nov., 1942.

Edward K. Morgan, *Aircraft Radio and ical Equipment*, Pitman Publishing Co.

S. Bond, *Direction Finders*, McGraw-Hill Co.

E. Terman, *Radio Engineers Handbook, tion Finding*, page 873, McGraw-Hill Co.

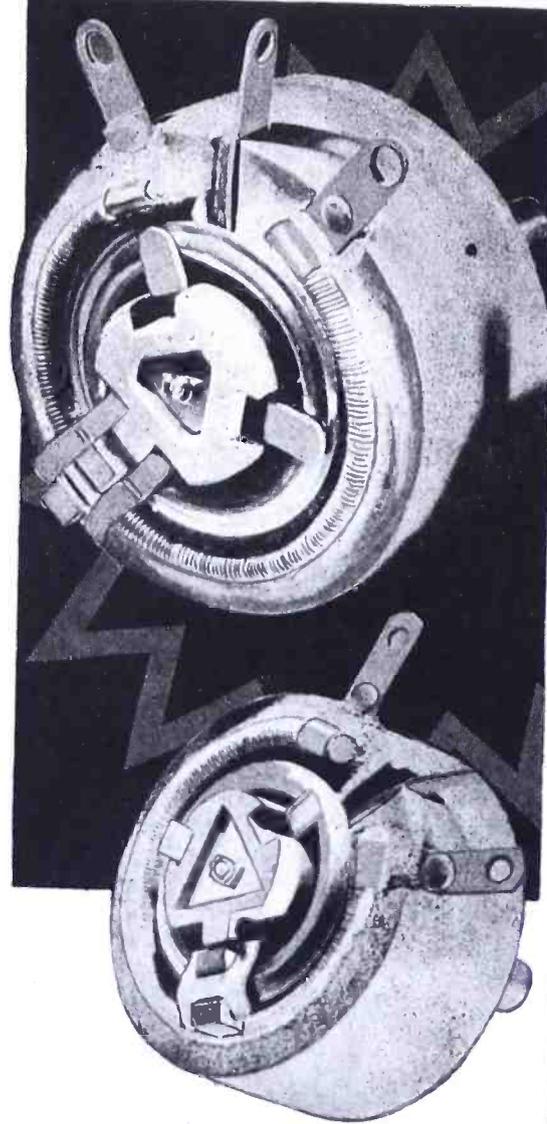
Charles M. McKee, *Radio Compass Calibra- COMMUNICATIONS*, March 1943.

safety regulations require that air- t while on the ramp or in the hangar quipped with a ground wire in a man- to prevent existence of difference of ntial between the aircraft and ground.

he test oscillator design and test pro- re described was devised by Eastern Lines Communications Department. basic idea is shown in the Sperry io Compass instruction book. The dard radio compass screen room test edure is given in Bendix Radio Test ublication Notes and also on page 140, *inciples of Aeronautical Radio Engi- ing* by P. C. Sandretto, McGraw- l Book Co.

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## RESISTIVE NETWORKS

(Continued from page 56)

basis treatment of networks, the terminations are of such values that looking either way at each of the terminal ends, the impedance seen is the same as that which would be provided by an infinite series of such networks connected in tandem.

The development of pure resistance networks may conveniently be made by means of matrix theory. And under conditions of proper methods of combination and the use of ideal transformers, networks having physically realizable constants in the majority of cases may be realized. The main field of usefulness of the matrix theory, where purely resistive networks are concerned, is that it enables us to combine several networks together in symbolic form to obtain a single network which will give the equivalence of the combination. A great saving in time of manipulation of network equations is generally obtained because of the compression of the mathematical forms of the mesh equations. It provides a powerful tool for analysis purposes, and the answers to many problems may be arrived at by matrix transformations without the actual necessity of making many and laborious calculations. However, since the present paper deals with single networks rather than groups of them in combination, the matrix forms will not be utilized.

The use of various theorems is very helpful to the network design engineer for purposes of analyses, and generally permit considerable simplification of many complex circuits into more manageable forms. However, the design of most commonly known and standard forms of purely resistive attenuating networks fortunately require only a few theorems to provide all of the tools necessary for the majority of applications.

### Equivalent Networks

The most useful transformations to the amateur, experimenter, sound studio and radio broadcasting engineer are those which transform one type of network to another, in order that more convenient and perhaps more economical commercial values of resistances may be used for either very high or very low values of attenuation.

### $\pi$ to $T$ and $T$ to $\pi$ Transformations

The  $T$  network of pure resistance type is equivalent at all frequencies to the  $\pi$  network shown in Figure 1, when the parameters have the values in Figures 2 and 3, as developed from

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he theory provided in equations 1 to 14 inclusive.

It should be noted that the transformations and formulae which follow throughout this series are perfectly general, and apply to networks having parameters or elements with impedances which are functions of a complex variable, as well as to resistances which are functions of a real variable which is a special case of the complex variable, in which the imaginary component equals zero. However, this fact will not be stressed in this paper because the elements of the networks considered here are assumed to be purely resistive over a frequency range extending into the megacycles. When the range of frequencies extends into the ultrahigh frequencies, special technique must be used, as the element which may resemble a pure resistance, with zero phase angle at a relatively low frequency, becomes a complex impedance at some higher frequency. This means that each resistance taken as a single unit becomes a highly complex network when the frequency is increased to a sufficiently high value. Self capacitance and lead inductance effects, as well as capacity to ground, then enter into the problem of design. It should not be interpreted by these remarks that the capacity to ground is of no importance in low frequency work, for this is far from being the case, especially if the level at which the networks are operated is low and high gain is required for an amplifier following the network.

#### $\pi$ to T Transformation

The impedances looking into terminals 1 and 3, 1 and 2, and 3 and 4 of both the T and  $\pi$  networks of Figure 1 must be equal if equivalence is to exist at all frequencies. Therefore we must have

$$u + v = \frac{b(a+c)}{a+b+c} = \frac{b(a+c)}{\Delta} \quad (1)$$

$$u + w = \frac{a(b+c)}{a+b+c} = \frac{a(b+c)}{\Delta} \quad (2)$$

and

$$v + w = \frac{c(a+b)}{a+b+c} = \frac{c(a+b)}{\Delta} \quad (3)$$

where  $\Delta = a + b + c$ .

Subtracting 3 from 1 + 2, and solving for  $u$  in terms of  $a$ ,  $b$ , and  $c$ ,

$$u = \frac{ab}{\Delta} \quad (4)$$

Subtracting 2 from 1 + 3, and solving for  $v$  in terms of the  $\pi$  elements,  $a$ ,  $b$ , and  $c$ ,

$$v = \frac{bc}{\Delta} \quad (5)$$



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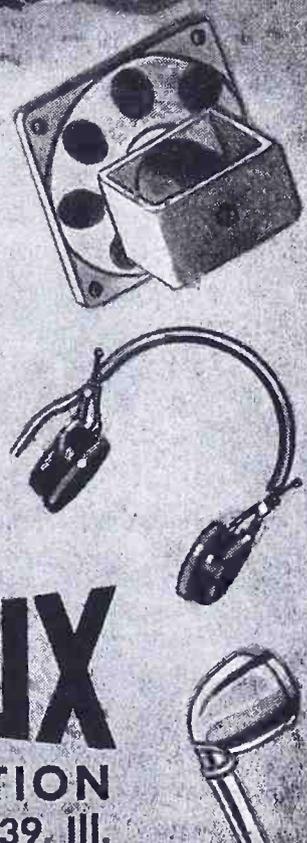
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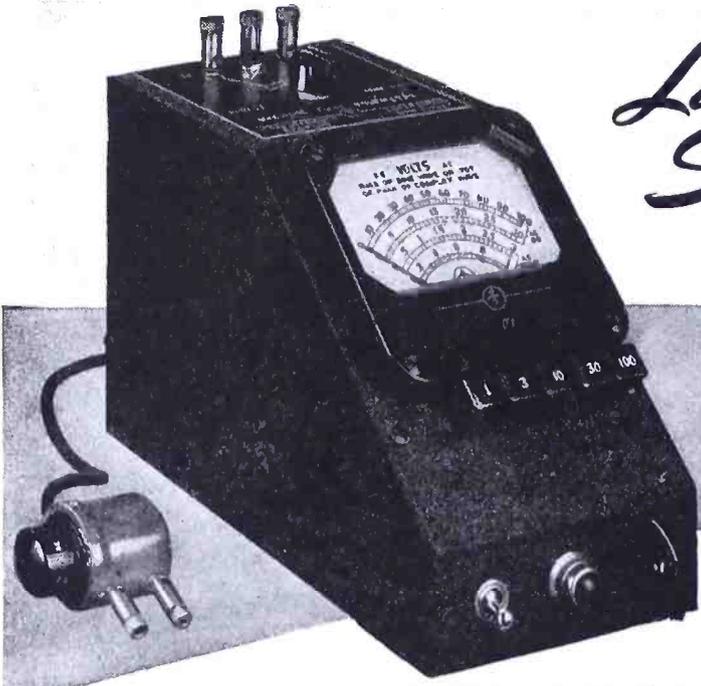
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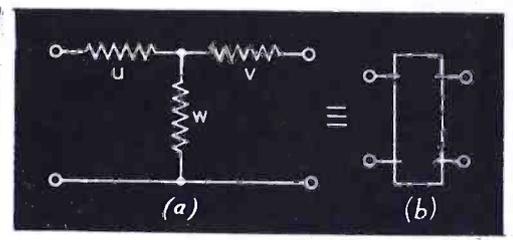


Figure 4  
The equivalence of a network having one set of elements within a four-terminal box to a simple T configuration.

Subtracting 1 from 2 + 3, and solving finally for w in terms of the known  $\pi$  network parameters, a, b, and c,

$$w = \frac{ac}{\Delta} \quad (6)$$

This transformation holds for all values of a, b, and c, whether they are composed of simple resistances or are complex impedances, and for pure resistance networks over all frequencies for which the treatment of the network elements as lumped constants is valid.

**T to  $\pi$  Transformation**

When the elements of the T network are given and it is desired to have the equivalent  $\pi$  network, the equations 4, 5 and 6 may be solved for a, b, and c in terms of u, v and w. Thus, taking the sum of the products of 4·5 + 4·6 + 5·6, we have

$$uv + uw + vw = \frac{ab^2c + a^2bc + abc^2}{\Delta^2} = \frac{abc}{\Delta} \quad (7)$$

and letting

$$\phi = uv + uw + vw \quad (8)$$

from 7 and 8

$$\frac{abc}{\Delta} = \phi \quad (9)$$

Taking the quotient of 9 and 5, 9 and 6, then 9 and 4 successively, term by term, the equations required are obtained as

$$a = \frac{\phi}{v} \quad (10)$$

$$b = \frac{\phi}{w} \quad (11)$$

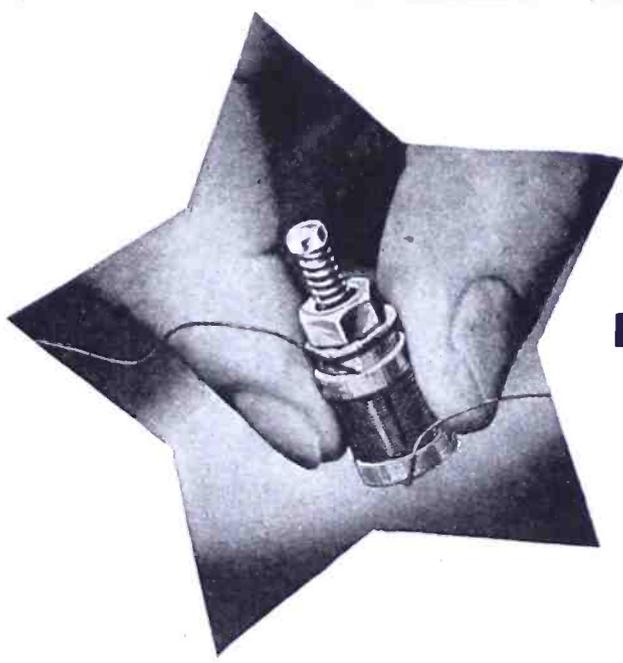
and

$$c = \frac{\phi}{u} \quad (12)$$

where  $\phi = uv + uw + vw$ .

As in the  $\pi$  to T transformation, these equations are perfectly general and apply for complex impedances as well as for simple resistances. This is valid in resistive networks for all frequencies over the range for which the lumped element circuit theory holds true.

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cal  $\pi$  network,  $a = c$ , and equations 4, 5, and 6 for the equivalent  $T$  become

$$u = \frac{ab}{2a + b} = v \quad (13)$$

$$w = \frac{a^2}{2a + b} \quad (14)$$

and for the symmetrical  $T$  with  $u = v$ , equations 10, 11, and 12 for the equivalent  $\pi$  become

$$a = u + 2w = c \quad (15)$$

$$b = \frac{u^2 + 2uw}{w} \quad (16)$$

A convenient form of showing the relationship between the  $T$  and  $\pi$  networks is given by Figures 2 and 3, where it may be seen that by placing the  $T$  and  $\pi$  elements at the vertices and sides of a triangle and in clockwise order as indicated, a workable "rule of thumb" method may be used for conversion purposes.

By repeated application of  $T$  to  $\pi$  and  $\pi$  to  $T$  transformations, any complicated network may be reduced to the standard form of  $T$  or  $\pi$  configuration.

#### Equivalent $T$ from Measurements of a 4-Terminal (2-Terminal Pair) Network

The equivalent  $T$  network for any configuration of elements, real, negative or complex, may always be found, although in many types of reactive networks it may not be physically realizable. However, in the pure resistance types considered here, the equivalent network is always physical and real over all frequency ranges for which the resistance elements have zero phase angles, and may be treated as lumped constants.

Let

$Z_{o1}$  = open circuit measurements with terminals 3 and 4 open, measured at terminals 1 and 2.

$Z_{o2}$  = open circuit measurements with terminals 1 and 2 open, measured at terminals 3 and 4.

$Z_{s1}$  = short circuit measurements with terminals 3 and 4 shorted, measured with terminals 1 and 2.

$Z_{s2}$  = short circuit measurements with terminals 1 and 2 shorted, measured at terminals 3 and 4.

Referring to Figure 4, these conditions may then be written

$$Z_{o1} = u + w \quad (17)$$

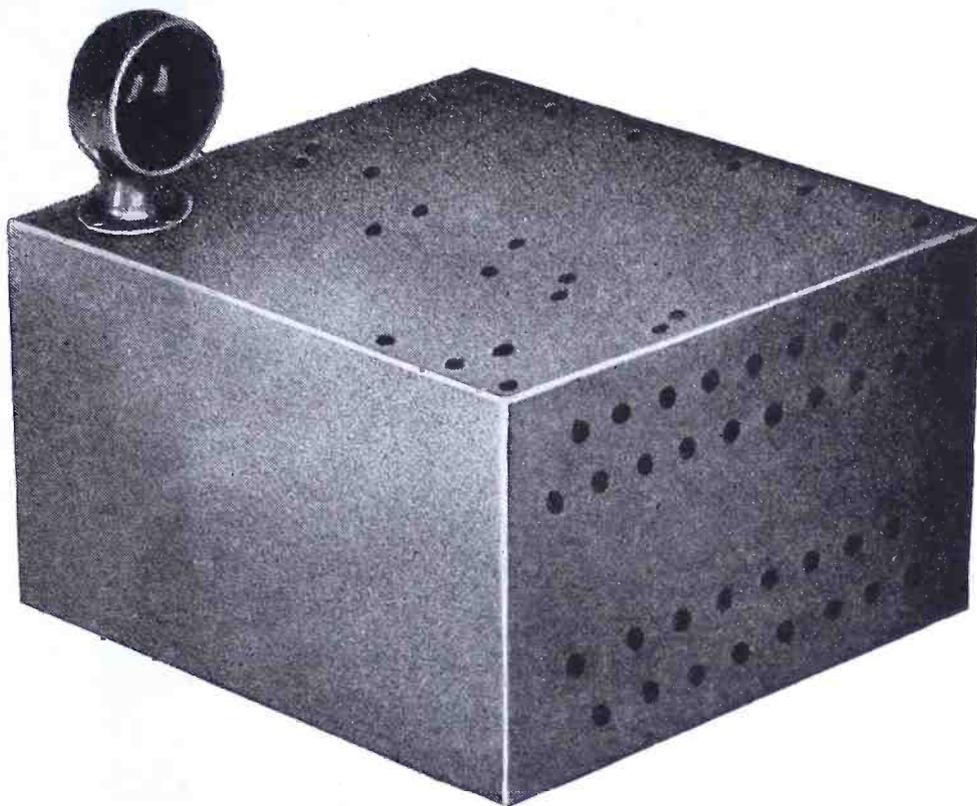
$$Z_{o2} = v + w \quad (18)$$

$$Z_{s1} = u + \frac{vw}{v + w} \quad (19)$$

$$Z_{s2} = v + \frac{uw}{u + w} \quad (20)$$

The products of equations 17 and 20,

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and 18 and 19 respectively give

$$Z_{01} Z_{02} = uv + vw + uw = Z_{02} Z_{03} = \Delta \quad (21)$$

This shows that if any three measurements of these four are made, the fourth can always be determined. Substituting 17 and 18 in 19 and solving for  $w$ , in terms of the measurements

$$w = \sqrt{Z_{02} (Z_{01} - Z_{03})} \quad (22)$$

Using 22 in 17 and 18 successively, the values required for the other two equivalent elements are obtained immediately as

$$u = Z_{01} - \sqrt{Z_{02} (Z_{01} - Z_{03})} \quad (23a)$$

$$= Z_{01} - w \quad (23b)$$

and

$$v = Z_{02} - \sqrt{Z_{02} (Z_{01} - Z_{03})} \quad (24a)$$

$$= Z_{02} - w \quad (24b)$$

In the special case of symmetrical networks giving equal open-circuit measurements, and equal short-circuited measurements,  $Z_{01} = Z_{02} = Z_{0c}$ ,  $Z_{01} = Z_{02} = Z_{0s}$ , and equations 23, 24 and 22 become

$$u = Z_{0c} - \sqrt{Z_{0c}^2 - Z_{0c} Z_{0s}} = Z_{0c} - w = v \quad (25)$$

$$w = \sqrt{Z_{0c}^2 - Z_{0c} Z_{0s}} \quad (26)$$

**Bartlett's Theorem<sup>1</sup>**

This theorem proposed by Bartlett and added to by Brune<sup>2</sup> provides one of the most useful tools of all those which are available to the communications engineer for network design problems. It treats of the bisection property of a class of artificial line sections. In essence, the theorem is stated that if an artificial line section with characteristic impedance  $Z_0$  and propagation function  $\theta$  has within itself  $n$  terminals 1, 2, 3, 4 . . . such that bisecting these terminals cuts the network into two exactly similar halves so that their behavior as determined with respect to the external terminal pairs is identical, and if each of the halves as considered from the original external pairs as a two-terminal impedance has an impedance  $Z_{oc}$  when terminals 1, 2, 3, 4 . . . are open and  $Z_{sc}$  when 1, 2, 3, 4 . . . are short circuited, then

$$Z_{oc} = Z_0 \coth \frac{\theta}{2} \quad (27)$$

and

$$Z_{sc} = Z_0 \tanh \frac{\theta}{2} \quad (28)$$

where  $\coth \theta/2$  and  $\tanh \theta/2$  are the hyperbolic cotangent and tangent respectively of the angle subtended by



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ch half of the complete network.  
 Since these hyperbolic functions are  
 reciprocal to one another, or

$$\tanh \theta/2 = \frac{1}{\coth \theta/2}$$

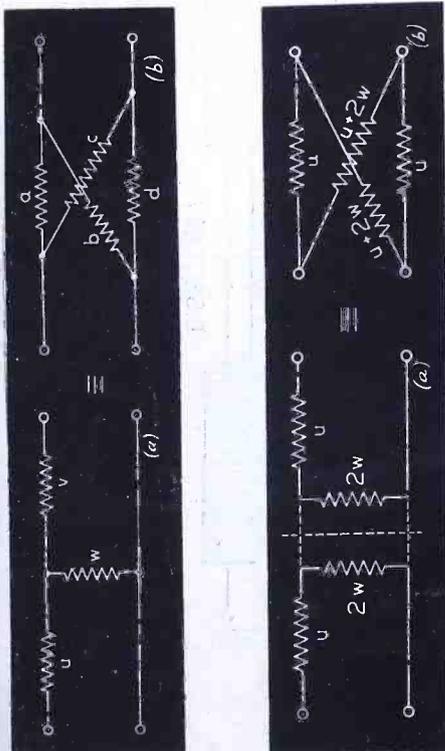
om 27 and 28, the characteristic im-  
 pedance may be found in terms of the  
 open and short circuited impedances  
 of the bisected network as

$$Z_0 = \sqrt{Z_{oc} Z_{sc}} \quad (29)$$

Relations 27 and 28 are exactly the  
 same as those for a symmetrical lattice-  
 type network and therefore any type  
 of network, for which the theorem is  
 valid, may be transformed into a lattice  
 configuration. Figures 6a and 6b show  
 the equivalence of a T-type network  
 to the lattice using these relationships.  
 Hence, we may note that the series,  
 shunt lattice equivalent is given by the  
 short circuited condition of the bisected  
 network and stated by equation 28,  
 while the shunt arms of the lattice  
 equivalent is given by the open cir-  
 cuit condition of the bisected net-  
 work and stated by equation 27. For  
 a lattice network equivalent of this

<sup>1</sup>Bartlett, A. C., *Phil. Mag.*, Vol. 4, pp. 902;  
 Nov. 1927.  
<sup>2</sup>Brune, O., *Phil. Mag.*, Vol. 14, Series 7,  
 p. 806; Nov. 1932.

Figures 5 (below, left) and 6 (below, right)  
 show the equivalence between elements of  
 the T and lattice networks. By imposing vari-  
 ous restrictions upon the lattice network, a  
 number of interesting and useful T networks  
 may be obtained. In Figure 6 (a) we have  
 a T-network which has been bisected and forms  
 two equal halves which have mirror-like sym-  
 metry. In (b), a lattice equivalent of the T-  
 network is obtained by inspection and the use  
 of Bartlett's Theorem applied to the bisected  
 network of (a).



Photograph Signal Corps, U. S. Army

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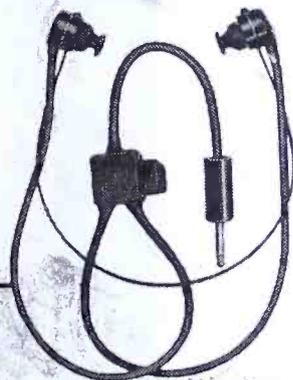
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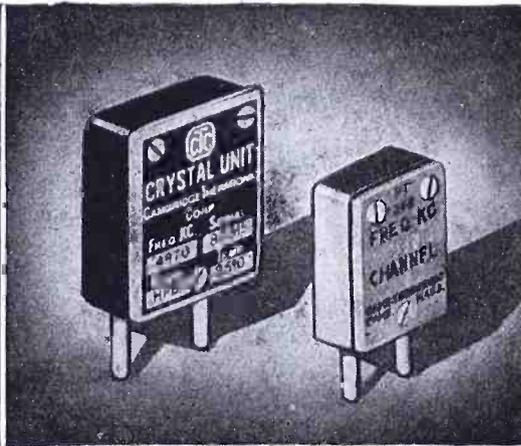
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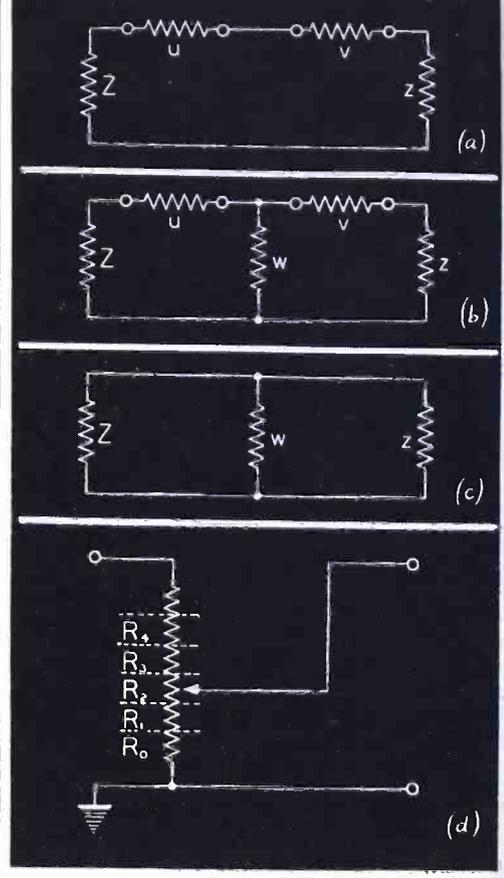
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Figures 7, 8, 9, and 10 Typical cases of a few of the classes of networks used in communications work.

type having series arms *a*, and shunt arms *b*,

$$a = Z_0 \tanh \phi/2 \quad (30)$$

$$b = Z_0 \coth \phi/2 \quad (31)$$

The characteristic impedance is from

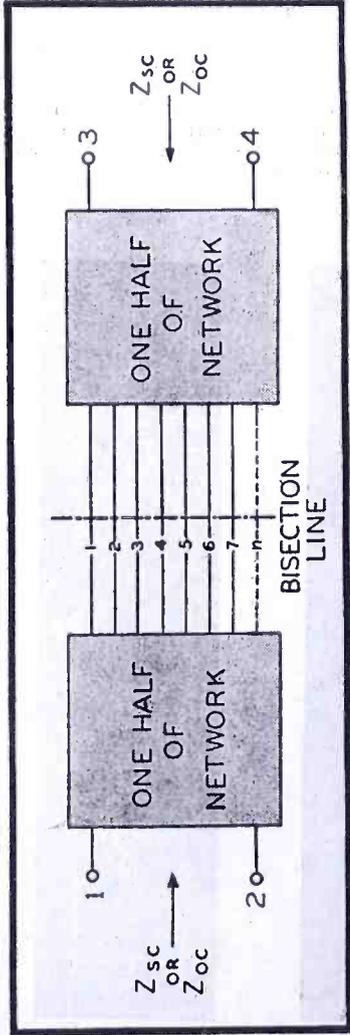
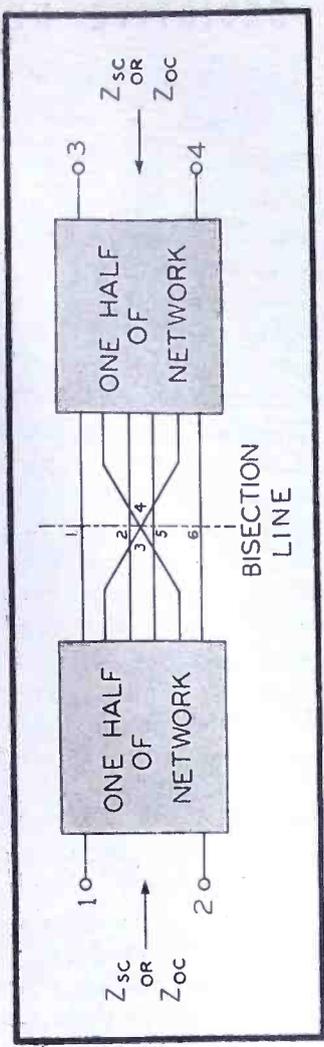


Figure 14 An example of Bartlett's Bisection Theorem as applied to a network with all connections taken straight through.

Figure 12  
An example  
of Bartlett's  
Bisection  
Theorem  
applied to  
symmetrical  
network  
having  
eight and  
crossed  
connections.  
(See text for  
and  $Z_{oc}$   
legend.)



and 31; therefore

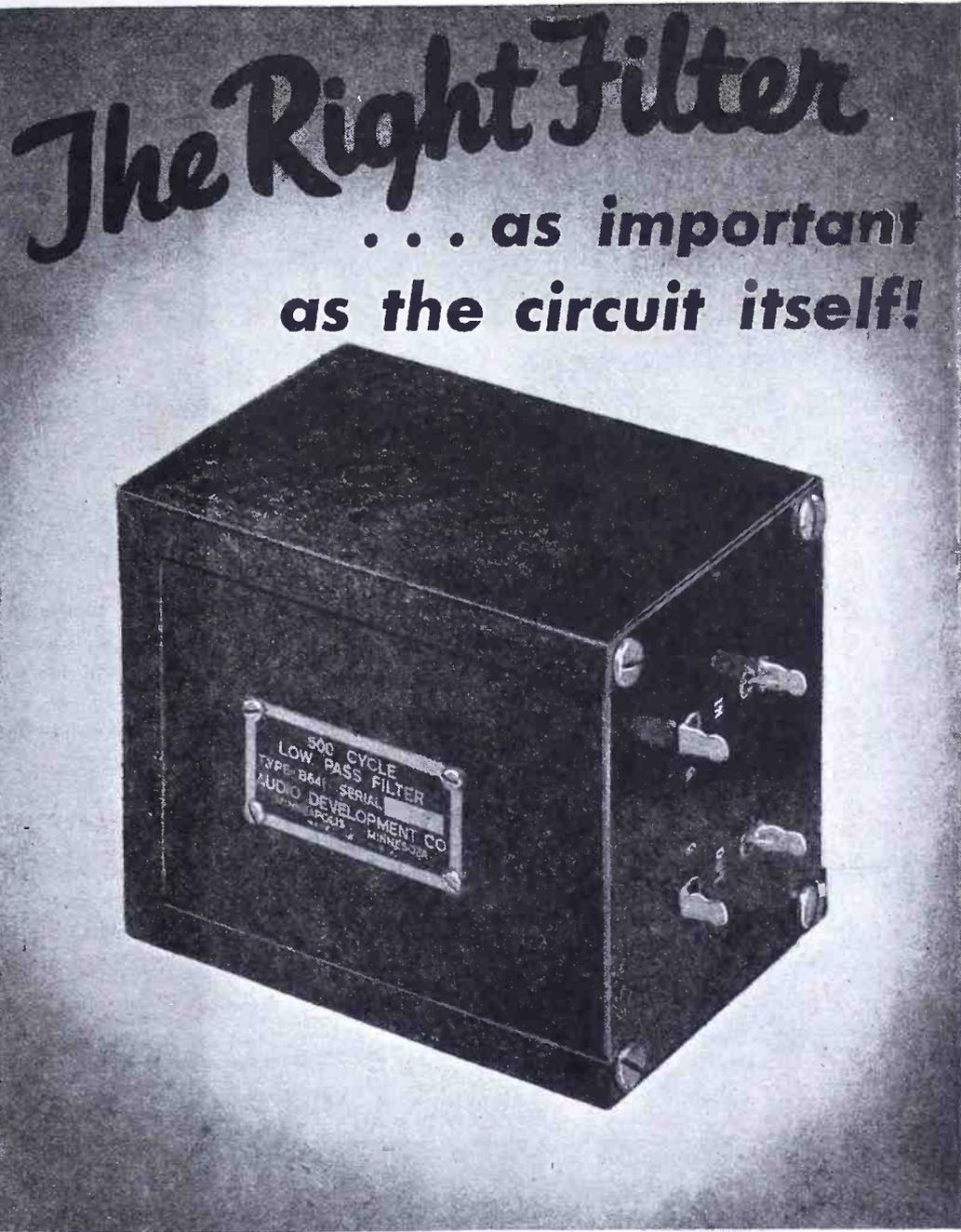
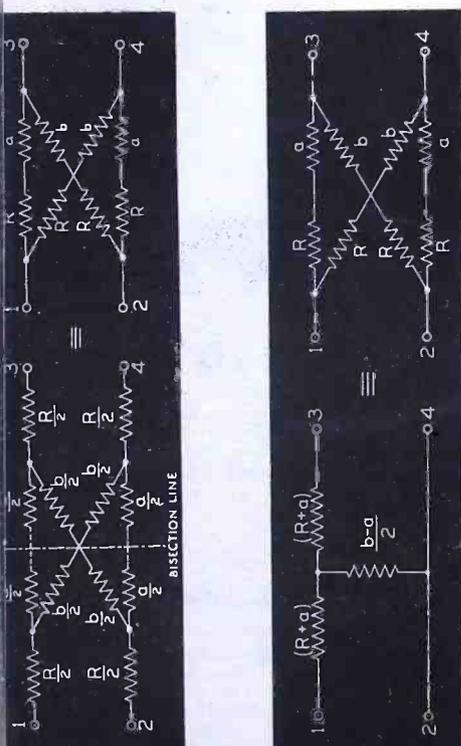
$$= \sqrt{V_{ab}} \quad (32)$$

The propagation function for the given network is found by the quotient of equations 28 and 27 as

$$= 2 \tanh^{-1} \sqrt{Z_{sc}/Z_{oc}} \quad (33)$$

and for the lattice equivalent, by equa-

Figures 13 (below, left) and 14 (below, right) Figure 13, an illustration of the application of the example shown in Figure 12. Figure 14, equivalent  $T$  of the lattices shown in Figure 13 by Bartlett's Theorem.

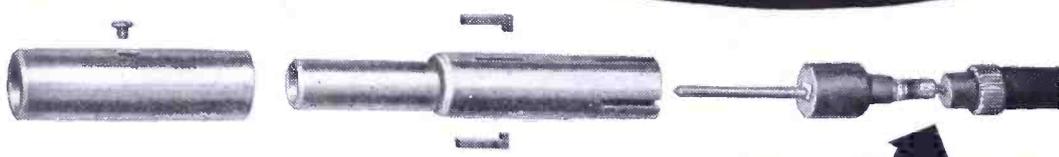


● Practical filter designs involve important compromises between several related factors if physical specifications and attenuation characteristics are to be achieved for predetermined circuit requirements. The overall performance of any design depends largely upon the carefulness and accuracy with which these considerations are carried out. Behind every ADC Filter stands years of practical design experience—the type of knowledge that makes it possible to turn out filters for the most exacting service applications.



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NO. 31

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Illustration shows panel with patch cord in place.

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## RESISTIVE NETWORKS

(Continued from page 77)

tions 30 and 31,

$$\theta = 2 \tanh^{-1} \sqrt{a/b} \quad (3)$$

Another class of networks having straight through and symmetric crossed connections may be reduced to a balanced lattice equivalence by applying the theorem, so that the equivalent series arm equals the input impedance of the bisected network when the straight through connections are all short circuited together and the crossed connections open circuited while the shunt arm of the equivalent lattice will be the input impedance of the bisected network when the straight through connections are all open circuited and the crossed connections are all short circuited together. This application of the theorem has a wide usage in transforming a lattice network having dissipative resistances within the lattice, to another lattice having the dissipative elements external to the equivalent lattice. Or the reverse may equally well be applied so that dissipative elements outside a lattice structure may be moved inside the equivalent lattice. These relationships may also apply to the transformation of the lattice network to the  $T$ ,  $\pi$  or bridged-types of networks.

## NEWS BRIEFS

(Continued from page 58)

Chicago, as sales and advertising manager after serving for 2½ years with the Douglas Aircraft Co. in Africa and the Middle East as a technical adviser and representative. Mr. Munger has announced the appointment of Magazines, Inc., as public relations counsel.



\*\*\*

### RCA CHART ON ASA SYMBOLS

To aid in the coordination of fundamental electrical graphical symbols, Radio Corporation of America is distributing a chart which explains and pictures the War Standards adopted recently by the American Standards Association. The new standards are recommended for electrical communications, power, control, and measurement diagrams, so as to eliminate any further confusion of symbols.

\*\*\*

### GOTHARD PILOT LIGHT CATALOG

A 24-page catalog and data book of pilot-light assemblies has been published by Gothard Manufacturing Company, 1300 North 9 Street Springfield, Illinois. The catalog contains illustrations, diagrams, specifications, prices, and other information on pilot-light assemblies for panel board and instrument signaling. Also in

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led are photos and descriptions of lamps, brackets and accessories.

**A REPORTS 65 APPLICATIONS FOR COMMERCIAL TELEVISION STATIONS**

Eighty-five applications from twenty-four states, for permission to erect commercial television stations, are now pending in FCC files in Washington, according to the Television Broadcasters Association, Inc. Proposed new stations are located in Boston, Hartford, New York, Philadelphia, Newark, Baltimore, Washington, D. C., Pittsburgh, Cleveland, Detroit, Cincinnati, Chicago, Milwaukee, New Orleans, St. Louis, Oklahoma City, Omaha, Denver, Lake City, Los Angeles, San Francisco, Spokane, as well as Rochester, New York; Richmond, Virginia; Jacksonville, Florida; Charleston, West Virginia; Lafayette, Indiana; Riverside, California; Stockton, California, and Albuquerque, New Mexico.

**OHMITE NEWS BULLETIN**

The June-July issue of "The Ohmite News" bulletin features an article on Army-Navy teletype equipment which is capable of sending twelve teletype messages simultaneously. A similar terminal system, which is now being used at the Kearney Works of Western Electric Company, is pictured. The bulletin also illustrates and describes Ohmite's close control and low resistance circular slide-wire rheostats, etc.

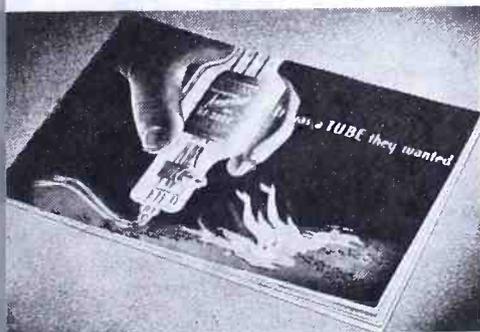
**KINGSBURY PROMOTED OPERADIO**

Harold H. Kingsbury, with Operadio Manufacturing Company for the past nine years, has been promoted to production control manager of the company's three plants in St. Charles, Missouri.



**AMPEREX TUBE BROCHURE**

A 24-page illustrated brochure entitled "It Was Tube They Wanted!" has been released by Amperex Electronic Corporation, 79 Washington Street, Brooklyn 1, New York. One section of the booklet photographically shows the plant operations at Amperex today. Mention is also made of the expected postwar activities of the company in producing their custom-built electronic tubes.



**O. B. HANSON NAMED TBA CONFERENCE CHAIRMAN**

The first annual conference of the Television Broadcasters Association, Inc., will take place in New York City on Thursday and Friday, December 7 and 8, 1944.

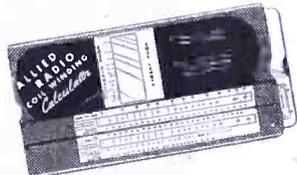
O. B. Hanson, vice president and chief engineer of the National Broadcasting Company and a director of TBA, will serve as chairman of the conference committee. Jack R. Poppele, secretary and chief engineer of WOR will be conference coordinator, and Will Baltin, secretary-treasurer of TBA will be in charge of press and public relations for the event.

**ASA LIGHTNING ARRESTER STANDARDS**

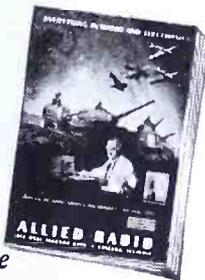
The American Standards Association has just (Continued on page 80)



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| Triplett | Knight           | Hammarlund     | Belden     | Utah     |
| Supreme  | Bliley           | E. F. Johnson  | Meissner   | Sangamo  |
| Mallory  | General Electric | Cutler-Hammer  | Amphenol   | Dumont   |
| Ohmite   | Cornell-Dubilier | Hart & Hegeman | Shure      | Bussman  |

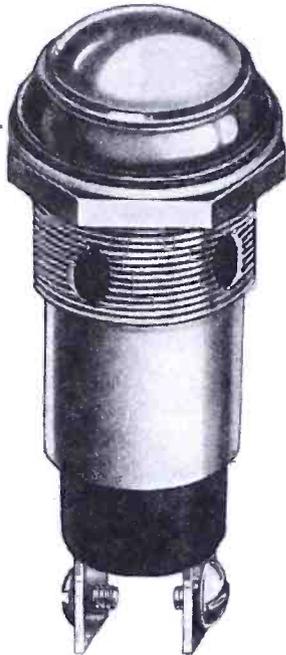
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# NEW

## Gothard

### NAVY SPEC.—BAKELITE BASE PILOT LIGHT

for 110 volt operation



This new light, with 1" jewel, is available in three models: #1032 faceted jewel; #1033 plain jewel, and #1034 frosted jewel, colored disc. Sockets are molded of bakelite to meet Navy specifications, 17P4-CFG. Removable jewel holder, of snap-in type, permits change of lamp from front of panel. 3/8" between terminals. Designed for Mazda 6S6 lamps. Selection of jewel colors: red, green, amber, blue, opal and clear—specify choice when ordering.

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## Gothard

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inclined eye-level control panel. Use one or two 8-ohm speakers without need of extra transformer. Has one 6SJ7GT, one 6SC7, two 6L6Gs in push-pull, two 6X5GTs. Model 6720, with tubes, F.O.B. New York \$56.28 Model 6721, same as 6720, less phono player, \$42.87

## TERMINAL RADIO CORP.

85 CORTLANDT ST. NEW YORK 7, N. Y.  
PHONE WOrth 2-4415

## NEWS BRIEFS

(Continued from page 79)

approved a revision of the American Standards for Lightning Arresters, first approved in 1936. These apply to substantially all the arresters designed for the protection of alternating current power circuits.

The standard enumerates certain operating conditions to be considered when selecting the arrester rating to avoid unnecessary damage to the arrester by misapplication. The standard is intended to be self-contained in respect to definitions, and new definitions for wave front, wave tail and wave shape are included. Standards also cover performance characteristics, service conditions and tests for lightning arresters.

One of the revisions made in this standard improves the technique of impulse testing in the measurement of both voltage waves and current waves.

These standards (C62.1-1944), are available from ASA, 29 West 39 Street, New York 18, N. Y. at 30 cents a copy.

### FARNSWORTH TELEVISION BROCHURE

A 26-page booklet entitled "The Story of Electronic Television" has been released by the Farnsworth Television & Radio Corporation. The booklet offers a simplified analysis of television reception and transmission. It is profusely illustrated with color pictures.

### CROCKETT NOW MERIT COIL S-M

John I. Crockett, Jr., has been named sales manager of Merit Coil & Transformer Corp., 311 No. Desplaines St., Chicago 6, Ill. He was previously with Thordarson Electric Mfg. Co., where he was chief expediter.

### WM. H. KELLEY JOINS MOTOROLA AS SALES MANAGER

Wm. H. Kelley has been named general sales manager of the Galvin Manufacturing Corp., 4545 Augusta Blvd., Chicago 51, Ill.

Mr. Kelley was formerly with RCA as regional manager of the San Francisco district.

The management of the Motorola sales and products organization is otherwise unchanged, according to Paul V. Galvin, president. Elmer H. Wavering will continue to head the car radio division, Walter H. Stellner will continue as manager of the home radio division, and N. E. Wunderlich remains sales manager of the police radio division. Advertising and sales promotion activities will be handled by Victor A. Irvine.



### PIONEER GEN-E-MOTOR NOW CORP.

The properties, assets and effects of Pioneer Gen-E-Motor of Chicago, a limited partnership, have been transferred to Pioneer Gen-E-Motor Corporation.

### FLOYD MASTERS NEW STEWART-WARNER RADIO DIV. MANAGER

Floyd Masters, midwest district manager for Stewart-Warner Corporation appliances, has succeeded L. L. Kelsey as manager of the company's radio division. This division will be reconverted to the manufacture of a-m and f-m consumer radio sets as soon as the war is over. Mr. Kelsey is now with Belmont Radio.

### AMPEREX REORGANIZES

Amperex Electronic Products, Brooklyn, N. Y., will hereafter be known as Amperex Electronic Corporation, and A. Senauke will serve as president.

N. Goldman, senior partner, has retired because of illness.

Nicholas Anton will serve as vice president

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# RADIO ANTENNA

## Premax Products

Division Chisholm-Ryder Co., Inc.  
4401 Highland Avenue, Niagara Falls, N. Y.

charge of manufacturing and Samuel Norris vice president in charge of sales. In the reorganization, Amperex becomes affiliated with North American Philips Company,



Samuel Norris

**WEXLER AND DENIUS JOIN MECK**

Charles R. Wexler and Homer R. Denius have joined the staff of John Meck Industries, Plymouth, Indiana. Mr. Wexler, who is taking over the post of chief engineer, was formerly with Ken-Rad Tube & Lamp Works and the Magnavox Corporation of Fort Wayne. Mr. Denius, new plant manager of Meck's electronic division, was previously associated with the Mosley Corporation.



Chas. R. Wexler



H. R. Denius

**ALTEC-LANSING AUDIO REACTOR DATA**

An 8-page reprint of a paper "High-Q Audio Reactor Design and Production," which originally appeared in the March issue of COMMUNICATIONS, has been released by Altec-Lansing Corporation, 1210 Taft Building, Hollywood 28, California. Colin A. Campbell, plant engineer, is the author.

**CANNON ELECTRIC CHART NO. 3**

A publication of Chart No. 3, "The Cannon Type K & RK Wall Chart," has been announced by Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles, California. The chart may be used as a visual aid on K and RK connectors by aviation schools, aircraft plants, air depots, flying fields, aircraft repair shops, and others, for the instruction, identification, assembly, ordering, servicing or repair of the connectors. It measures 38"x50", and may be obtained without cost upon request.

**G. E. POSTWAR RADIO-TELEVISION CATALOG**

A 28-page, four-color catalog on postwar prospects of radio and television has been issued by General Electric Company, 1 River Road, Schenectady, New York. The catalog, "Your Coming Radio," forecasts through illustrations, the innovations which will be available to the public after the war, from improved tubes to late model cabinet designs.

**WCEMA ADDS SIX MEMBERS**

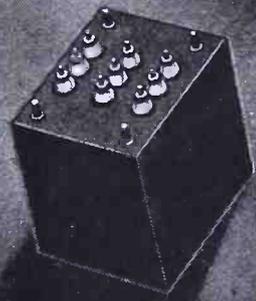
Six new members have been accepted into the West Coast Electronic Manufacturers Association. They are: Brittain Sound Equipment Co., Los Angeles; Merle F. Faber—Manufacturing, San Francisco; Harvey Machine Co. Inc., Los Angeles; Howard Pacific Corp., Los Angeles; The Lake Mfg. Co., Oakland; and Special Electric Laboratories, Los Angeles. This brings the total membership to more than fifty.

**JENNINGS VACUUM CONDENSER FOLDER**

A 4-page folder describing the 20-ampere series VC 6-50 vacuum condenser, is being distributed by Jennings Radio Manufacturing Company, San Jose, California. The folder features a (Continued on page 82)



*Battle-Tested!*



Before a Stancor Transformer is shipped, it is "certified for service" by engineers whose tests simulate actual conditions in the field... Because "Stancor" is battle-tested—right in our extensive laboratories—it has covered itself with glory on the battlefield. This is your assurance of the efficient performance of Stancor Products to which you may confidently look when the domestic market returns.

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**Products of "MERIT" are passing the test**

Complying with the most exacting requirements for precision workmanship and durable construction. MERIT has established its ability to produce in quantity and deliver promptly—

Transformers • Coils • Reactors • Electrical Windings of All Types for Radio, Radar and Electronic Applications.

Today these dependable MERIT precision parts are secret weapons; tomorrow when they can be shown in detail as MERIT standard products you will want them in solving the problems of a new electronic era.

Illustrated: High Voltage Transformers A-2123 (small) and A-2124. Designed for high altitudes. Oil-filled and Hermetic sealed.



**MERIT COIL & TRANSFORMER CORP.**  
311 North Desplains St. CHICAGO 6, ILL.

**NEWS BRIEFS**

(Continued from page 81)

temperature versus capacity curve, operating characteristics, and design data.

\*\*\*

**LESLIE THOMAS NOW  
SOLAR WORKS MANAGER**

The Solar Manufacturing Corporation of Bayonne, New Jersey, has appointed Leslie C. Thomas as works manager. Mr. Thomas was formerly vice president and works manager of International Resistance Corporation.



\*\*\*

**SPRAGUE DRY ELECTROLYTIC  
CAPACITOR CATALOG**

A 28-page catalog, No. 10, describing dry electrolytic capacitors has been released by Sprague Electric Company, North Adams, Mass. The catalog describes the combination of capacity and voltage ratings available, with special electrical characteristics and in containers for every mechanical requirement. Types cataloged include cardboard and metal tubulars, cylindrical metal container types, high-capacity low-voltage cylindrical "FP" types, octal base, a-c motor starting, and special purpose types. Pages are also devoted to application notes including a number of typical characteristic charts.



\*\*\*

**LAPORT AND KNOX RECEIVE NEW  
RCA INTERNATIONAL POSTS**

Edmund A. Laport has been appointed staff engineer for international communications systems and special apparatus at RCA, Camden, N. J. James B. Knox succeeds Mr. Laport as chief engineer for engineering products at RCA's Canadian subsidiary, RCA Victor Ltd.

In 1928 Mr. Laport built three mobile railway transmitter stations for the Chinese government at Peking and Tsientsin. Later he installed Rome's 1 RO (located near the Anzio beach head) and Milan's 1 MI.



J. B. Knox



E. A. Laport

\*\*\*

**OPERADIO DISTRIBUTOR BULLETIN**

The first issue of a news-letter, "The Operadio Bulletin," is being mailed to distributors, source service men, and industrial music outlets by Operadio Manufacturing Company, St. Charles, Illinois. Additional news-letters are expected.

# EASTERN PUMPS FOR VACUUM TUBE COOLING SYSTEMS

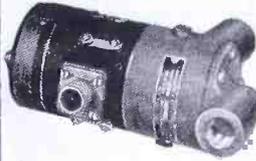
Five different models of small centrifugal pumps designed for circulating water through the cooling systems of communication and X-ray tubes have been successfully designed by Eastern Engineering Company, long a leading manufacturer of small pumps for big jobs. These pumps may be had for either land, sea or airborne installations.

## AIRBORNE MODELS

(Designated as the AR Series)

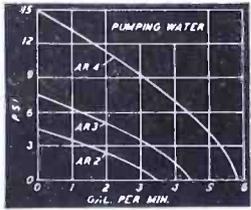
These are designed in conformance with Army and Navy standards. They have the following outstanding features:

- EXTREMELY LIGHT WEIGHT • COMPACT • INTEGRAL PUMP AND MOTOR UNIT • EXPLOSION PROOF • VARIED PERFORMANCES AVAILABLE • OPTIONAL VOLTAGES • LONG LIFE - CONTINUOUS DUTY • DEPENDABLE OPERATION • UNIVERSAL MOUNTING



The pump and motor are one integral unit weighing but two and one-third pounds and measuring over-all 5 3/8" x 4 1/2" x 2 1/2".

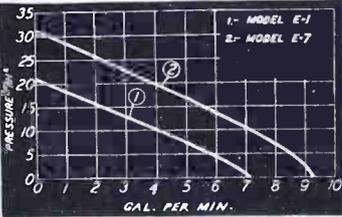
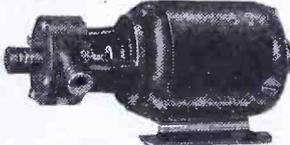
Performance up to 11 P. S. I. and up to 5 gallons per minute. Models are available in standard 12 and 24 volt D. C. ratings. Shown are performance curves for the AR2, 3 and 4. All models have long life and are rated for continuous duty with the exception of model AR4, which under 8 P. S. I. is rated for intermittent duty. While the curves shown are those for which production is now standard, it is readily possible to obtain other characteristics where quantity is involved.



The pump is equipped with a mechanical rotary seal which positively seals against any leakage. This seal is adjusted at the factory and tested under excessive pressure. Once the pump has been released from the test room no further attention or maintenance is necessary for either motor or pump during the life of the unit.

## LAND AND SEA MODELS

(Designated as E-1 and E-7)



Both are centrifugal pumps, powered by General Electric Universal Motors. Model E-1 is 7" x 3 3/8" x 3 3/8", 1/15 H. P., weighs 6 lbs. and has a Maximum Pressure of 20 lbs. P. S. I. with a Maximum Capacity of 7 G. P. M. Model E-7 is 9" x 4" x 4", 1/5 H. P., weighs 8 lbs. and has a Maximum Pressure of 30 lbs. P. S. I. and a Maximum Capacity of 9 G. P. M. Performance curves for both models are shown above. Both of these models are designed for long life. They are equipped with mechanical rotary seals which completely seal the pumps against leakage. While the curves shown are those for which production is now standard, it is readily possible to obtain other characteristics where quantity is involved. They can be obtained with motors to meet Navy Specifications.

**EASTERN ENGINEERING COMPANY**  
171 FOX STREET - NEW HAVEN 6, CONN.

dealers of sales developments and electronics trends. Fred Wilson, sales manager for the commercial sound division, is editorial director of the bulletin.

## McNAMEE AND AKIN JOIN LITTELFUSE

Littelfuse, Inc., of Chicago, Illinois, and El Monte, California, has announced the appointment recently of Bernard F. McNamee as head of electronic research, and R. G. Akin as mid-west division sales manager.

Mr. McNamee was formerly director of the engineering department of Consolidated Engineering Corporation, Pasadena. His previous associations include service with Wagner Electric Company, the Echophone Company, Colin B. Kennedy Corporation, Rieber Laboratory, Moorehead Laboratories, and the Superior Oil Company.

## GIRARD-HOPKINS CATALOG

A 12-page catalog describing dry and wet electrolytics, paper tubulars, filter capacitors, oil-filled capacitors, interference filters and power factor capacitors has been published by Girard-Hopkins, Oakland, California.

## HUDSON-AMERICAN ENGINEERING DIGEST

A digest of outstanding technical papers appears in the first issue of the "Radio Engineers Digest," published by the Hudson-American Corporation, 25 West 43 Street, N. Y. City, edited by John F. C. Moore. Included in this issue is Professor Paul Hudson's paper on "Demodulation Waves" which appeared in the April issue of COMMUNICATIONS.

## DIALCO DATA CATALOG

A 24-page catalog, No. 43, has been issued by Dial Light Company of America, Inc., 900 Broadway, New York 3. Photographs, diagrams, charts, physical and electrical characteristics, and other general information on Dialco pilot light assemblies and accessories are given.

# Openings for . . . RADIO ENGINEERS ELECTRICAL ENGINEERS MECHANICAL ENGINEERS

In the development and production of all types of radio receiving and low-power transmitting tubes. Excellent post-war opportunities with an established company in a field having unlimited post-war possibilities.

Apply in person or in writing to:  
Personnel Manager  
**RAYTHEON  
MANUFACTURING CO.**  
Radio Receiving Tube Division  
55 Chapel St., Newton 58, Mass.



# MEASURES QUANTITIES

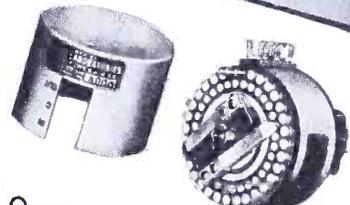
with greater  
sensitivity & range  
than ever before  
accomplished



PATS. APP. FOR

## TECH LAB MICROHMMETER

. . . gives direct and instantaneous readings of resistance values down to 5 microhms and up to 1,000,000 megohms. Accuracy in all measurements to better than 2%. Output is sufficient to drive recorder. Entirely AC operated. Furnished in two models. Reasonably prompt deliveries. For complete data regarding other applications write for Bulletin No. 432.

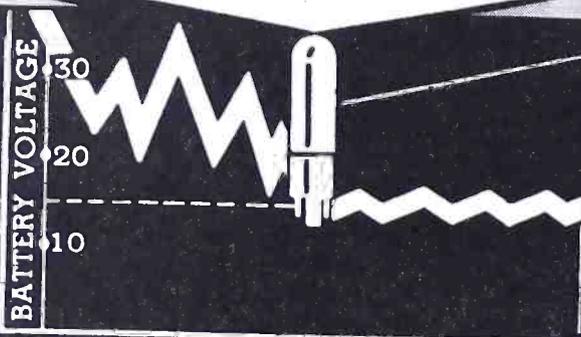


Quality manufacturers of attenuators and other electrical resistance instruments. For complete data write for Bulletin No. 431.



1 LINCOLN STREET  
JERSEY CITY 7, N. J.

# ENGINEERS: Here's the BIG POINT about **AMPERITE REGULATORS**



VOLTAGE OF 24V  
BATTERY & CHARGER  
VARIES APPROX.

**50%**

WITH AMPERITE  
VOLTAGE VARIES  
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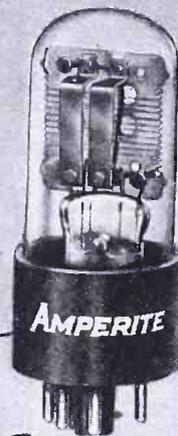
**2%**

**DELAY RELAYS:** For delays from 1 to 100 seconds.  
Hermetically sealed. Unaffected by altitude. . . . Send for catalogue sheet.

NEW! 4-page folder will help you solve Current and Voltage Problems;  
contains much valuable data in practical form—Write for your copy now.

**AMPERITE CO., 561 Broadway, New York (12), N. Y.**

In Canada: Atlas Radio Corp., Ltd., 560 King St., W. Toronto



### Features:

1. Amperites cut battery voltage fluctuation from approximately 50% to 2%.
  2. Hermetically sealed — not affected by altitude, ambient temperature, humidity.
  3. Compact . . . light . . . and inexpensive.
- Used by U.S. Army, Navy, and Air Corps.



## OUT OF THE BLACK EARTH

ASTATIC has so planned it that out of black earth come beautiful flowers and the foods essential to our very sustenance. And so it is that from the darkness of the present hour . . . from the suffering and sacrifice of world war . . . will emerge a greater degree of understanding among men . . . more freedom for untold millions . . . and advanced ideas to make man's burdens lighter and life more enjoyable. Astatic, like so many other manufacturing concerns, has been broadened by the experience of war production, has employed its engineering skill and manufacturing facilities to create new products, the principles of which will be reflected in Astatic's commercial and civilian products of a new day.

**ASTATIC**

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CANADIAN ASTATIC, LTD.  
TORONTO, ONTARIO

**THE ASTATIC CORPORATION**  
YOUNGSTOWN, OHIO

## THE INDUSTRY OFFERS . . .

(Continued from page 62)

tic or corrosive fumes, oil, grease, acids, alkalis or moisture.

A general sample for testing will be sent by the manufacturer on request.

\* \* \*

### SPERTI HERMETIC SEALS

Hermetic seals of glass and a metal that has an expansion coefficient similar to glass and said to be capable of withstanding severe thermal shock, are now being produced by Sperti Inc., Cincinnati, Ohio. The seal is said to provide a vacuum-tight bond that resists any type of corrosion, atmospheric or liquid. Each seal can be soldered to plates and cases by means of high frequency oven soldering or standard soldering iron and the soldering temperature is not critical. Two small eyelets on both ends of the protruding shaft of the seal allow for wire attachment to transformers, condensers, relays and miscellaneous radio components. A hydrogen pressure-test for leaks and many other rigid inspections are part of the manufacturing process.

The glass insulation is said to provide a high flash over seal which will not carbonize. Navy immersion tests are said to show it to have a leakage resistance of 30,000 megohms, minimum. Has a thermal operating range from -70° C to 200° C.

Seals are available in special shapes and sizes either as single terminals or multiple headers. Some employ tubing instead of wire rod.



\* \* \*

### PLASTIC LACING CORD

Vinylite lacing cord for tying wire has been announced by the Art Chrome Company of America, 141 Malden Street, Boston 18, Mass.

Its specific gravity is said to be 1.30; tensile strength, 2400 psi; elongation at break, 250%; maximum operating temperature, 70° C. Power factor at 1,000 cycles per second and at 30° C is 126.

Not soluble in alcohols or carbon tetrachloride.

\* \* \*

### PRICE ROTARY RELAY

Relays operating on a rotating balanced principle have been announced by Price Brothers Company, Frederick, Md.

The basic unit of the relay, known as "Rotrol," is said to be a compact driving mechanism providing up to 30° of clockwise or counter clockwise rotation.

When used to operate switch wafers, it is said to provide a variety of contact arrangements adaptable for spaced wafer switches or switches in separate compartments. Where switch wafers are not used a special self-contained coil break switch is provided.

Measures 2½"x1½"x1¼".

\* \* \*

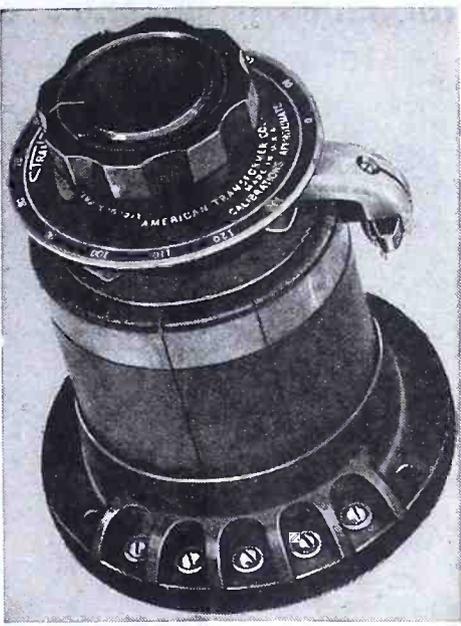
### AMERTRAN TH TRANSTAT

A transformer type a-c voltage regulator, type TH Transtat, has been developed by American Transformer Co., 172 Emmet Street, Newark 5, N. J. The brush arm is a machine die casting. The shaft is independent of the brush arm assembly and can be removed by drawing one pin. Thus, the unit can be changed from panel mounting to table mounting or ganged with other units for polyphase or simultaneous single phase control. By employing a phenolic thermosetting plastic base, high dimensional conformance is said to be assured and accidental lead shorting is prevented.

Unit also features vinyl acetal insulated wire, impregnated core and coil with synthetic phenolic resin varnish of the polymerized type, and a dual-mounting arrangement for open delta three-phase control.

Type TH-2½A Transtat, 50-60 cycles, 115 volts, for single-phase operation, 35° C rise, has a nominal va of 250, output volts of 0-115 and output amperes 2.17; a maximum va of

0, output volts of 0-130, output amperes 2.17. At 50° C rise, nominal va is 300, output volts 115, output amperes 2.6; maximum va is 340, output volts 0-130, output amperes 2.6. Type TH-2X-2½A Transtat dual unit, open delta connected for 3-phase regulation, 50-60 cycles, 115 volts, 35° C rise, has a nominal va of 435, output volts 0-115, output amperes 2.17; maximum va of 485, output volts 0-130, output amperes 2.17. At 50° rise, nominal va is 520, output volts 0-115, output amperes 2.6; maximum va is 590, output volts 0-130, output amperes 2.6. Output voltages are full load voltages. No load voltages may be expected to be approximately 5% higher. Exciting current is 0.06 amperes. Voltage increments are 0.4 throughout range of control. Single unit weighs 5.5 pounds; dual unit 12 pounds.



**3-POINT PIPE GAGE**

A three-point pipe gage to measure pipe from 1/8" to 12", and electrical conduit and metallic tubing, has been produced by the Three-Point Gage Co., 3821 Broadway, Chicago 13, Ill. Gage is pocket size. Consists of two pivoted steel plates with edges curved at three points for contact with the pipe or tubing to be measured, together with scales which register standard sizes of electrical metallic tubing (thin-wall tubing) and conduit, and also correct sizes of pipe in terms of inside measurement. A third scale shows drill size for tapping. Also included is an inch rule and metric rule. Constructed of steel, finished in black rust proof finish. Size, when closed, 2 3/4" x 4 1/2".

**FUNGUS COATING**

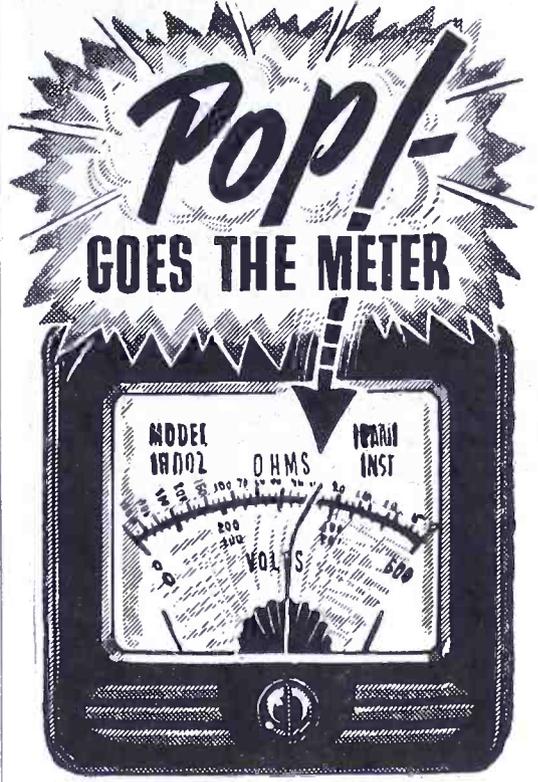
Moisture and fungus resistant coating for over-all treatment of assembled ground equipment, has been announced by Insl-x Co., 857 Meeker Ave., Brooklyn, N. Y. Approved under Signal Corps, spec. 71-2202 A. The material, Insl-x No. 25-A, is said to become "tack-free" in less than 15 minutes... hard in less than an hour. It is said to be non-toxic to humans. Official tests are also said to show Insl-x No. 25A will not cause dermatitis.

**PIVOT TYPE BALL BEARINGS**

Pivot type ball bearings are now available from Miniature Precision Bearings, Keene, New Hampshire, in sizes ranging from 2-10 mm o-d. Made of beryllium, stainless or chrome steel as required for the application. Bearing races are machined from solid bar stock and finished on raceway and exterior surfaces. Each bearing is equipped with four balls of the same material as the cup and fitted with a retaining cap.

**VOLTAGE-BREAKDOWN TESTER**

For testing voltage breakdown of materials. (Continued on page 86)

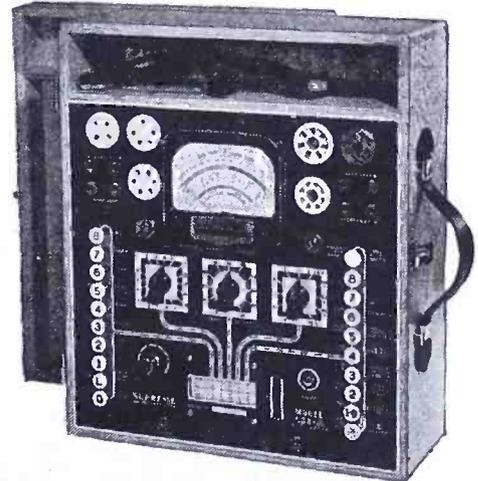


What happened to your meter when you made a miscue and slammed the pointer against the stops? Does the pointer above revive unpleasant memories?

Until Supreme started production of its own meters, the best general purpose meters available were secured for our test equipment. They were good... as good as any general purpose meter can possibly be. Today, however, Supreme built meters are designed for one specific field... the electronic service man.

Think back over the past years. How many days and dollars have you lost because of a slammed meter? No meter is indestructible, but these Supreme Meters can take it. Accurate? Yes! And double-rugged!

Investigate when considering post-war service equipment.



Supreme 504-A Tube and Set Tester. One of many test instruments incorporating a Supreme Meter.

**The Answer TO YOUR PROCUREMENT PROBLEMS**



OVER 10,000 ITEMS IN STOCK  
FAST DELIVERY  
Assured on Priority  
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INDUSTRIAL ELECTRONIC EQUIPMENT

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**SUN RADIO & ELECTRONICS CO.**  
212 Fulton Street, New York 7, N. Y.

**JONES 500 SERIES PLUGS AND SOCKETS**

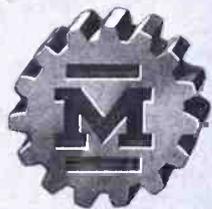
Designed for 5,000 volts and 25 amperes. All sizes polarized to prevent incorrect connections, no matter how many sizes used on a single installation. Fulfill every electrical and mechanical requirement. Easy to wire and instantly accessible for inspection. Sizes: 2, 4, 6, 8, 10, and 12 contacts. Send for a copy of Bulletin 500 for complete information. Write today.



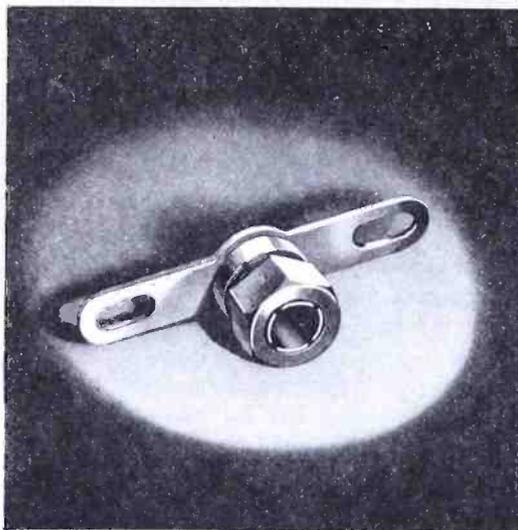
**HOWARD B. JONES CO.**  
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**SUPREME**  
SUPREME INSTRUMENTS CORP.  
GREENWOOD, MISSISSIPPI, U. S. A.

*Designed for*



*Application*



**The No. 10060  
Shaft Lock**

Another exclusive Millen "Designed for Application" product is the No. 10060 shaft lock. This differs from the self-mounting No. 10061 unit in that it is mounted on a cross arm which can readily be attached to variable condenser frames, brackets, etc., for "behind the panel" applications.

**JAMES MILLEN  
MFG. CO., INC.**

MAIN OFFICE AND FACTORY  
MALDEN  
MASSACHUSETTS



Industrial Instruments, Inc., 17 Pollock Ave., Jersey City, N. J., have developed a voltage breakdown tester. Operating range of instrument, type P-3, is 0 to 10,000 volts d-c, or 0 to 8,000 a-c. A lower range instrument, type P-1, with sloping panel, has a range of 0 to 4,000 volts d-c, or 0 to 3,000 volts a-c. The voltage is continuously variable over the entire range. Tester operates directly from 110-130 volt 50/60 cycle a-c line. Breakdown is indicated by a red signal light, while a built-in meter indicates the direct-reading voltage. Drawer-switch type fixtures are available. These fixtures have a jig to take given components or materials, and when the drawer is closed the voltage is applied. External connections are made by means of an insulated plug inserted in the high-potential a-c or d-c jack, with the other side grounded.

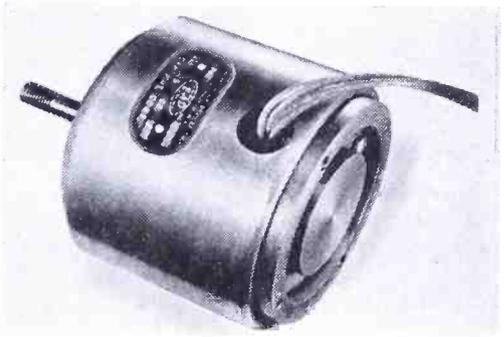
Housed in metal cabinet, 15"x21"x28".

**EASTERN AIR 1/50 H-P MOTOR**

Midget motors for driving blowers in high ambient temperatures and for powering small control devices of all types have been developed by Eastern Air Devices, Inc., 585 Dean Street, Brooklyn 17, N. Y.

Motors can be supplied to deliver 1/25 h-p.; can be wound for 2 or 3 phase and also furnished for 400-cycle applications at higher speeds and h-p.

Specifications: 60 cycles; 115 volts; single phase—3400 rpm; diameter 3 5/16"; overall length 3 1/8"; shaft diameter 5/16"; weight 3 pounds.



**HYTRON MINIATURE TUBES**

Three new miniature tube, types 6AK5 6AL5, 6AQ6, have been announced by Hytron Corporation, Salem, Massachusetts.

The 6AK5 is a sharp cut-off r-f pentode; 6AL5, a v-h-f twin diode; and the 6AQ6, a double diode triode.

**VACUUM PACK STORAGE BATTERIES**

A vacuum-pack type of storage battery has been developed by the Willard Storage Battery Company.

Four batteries—three 36-volt types and one 6-volt—are packed in a lead-plated metal container from which the air is exhausted. The batteries are said to retain their charge indefinitely and be ready for immediate use regardless of the time elapsed since their manufacture, or distance they have been transported from the factory.

When the batteries are about to be placed in service, the can is punctured by a special filling device and the vacuum inside the can draws the electrolyte quickly into 18 minia-

of seconds, says the manufacturer, each battery is filled with electrolyte.

The 36-volt battery measures slightly over 4" in length, just under 1 1/2" in width and less than 1" in height; weighs six ounces.

Its case is made of polystyrene.

**GLASS-LENS INDICATING LIGHT**

An indicating light for service on 120 volts, featuring a small diameter mounting hole and a threaded type lens-cap, is now available from The H. R. Kirkland Company, Morristown, New Jersey.

Known as the 590 D/E unit it mounts in a single 3/8" diameter hole.

The lens-cap is said to contain a heavy walled glass lens, cupped in shape. The tip of the S6 standard 120-volt lamp bulb extends into the cup of the lens, facilitating servicing of the bulb. This lens design is also said to provide 180° visibility. Lenses are available in red, green, blue, amber and white with the

*Permanent*  
**MAGNETS**  
*By*  
**Thomas & Skinner**

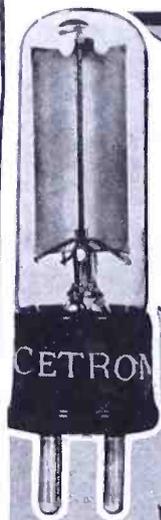
ALL SHAPES... ALL SIZES  
Cobalt • Chrome • Tungsten  
Stamped, Formed or Cast.  
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Also: LAMINATIONS for output transformers of highest permeability. Standard stocks in a wide range of sizes for Audio, Choke, Output and Power Transformers. Write for dimension sheet. . . . TOOLS . . . DIES . . . STAMPINGS . . . HEAT TREATING.  
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**OUTSTANDING  
QUALITY!**

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Special Tubes*

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on most types  
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# TECHNICAL NOTES

Excerpts from New Home Study Lessons Being Prepared Under the Direction of the CREI Director of Engineering Texts

## Phase Inverter Circuit

Last month, CREI presented the first part of a technical article describing the Phase Inverter Circuit. Part 2, which appears in the September issue of "THE CREI NEWS," gives a typical numerical example of the Phase Inverter Circuit and indicates the type of performance that can be expected.

Derivations are then made of the gain and stability of gain of such a stage and it is shown that very good results can be expected. Finally, an analysis of the input admittance is made, as well as remarks on some practical features of the circuit.

Each month "THE CREI NEWS" features such a technical article, in addition to other interesting features concerning The Institute and the industry. We shall be glad to add your name to the mailing list without obligation. Simply write to The Institute at the address below and request the September issue of "THE CREI NEWS" containing the article on the Phase Inverter Circuit.



The subject of "Phase Inverter Circuit" is but one of many that are being constantly revised and added to GREI lessons by A. Preisman, Director of Engineering Texts, under the personal supervision of CREI President, E. H. Rietzke. CREI home study courses are of college calibre for the professional engineer and technician who recognizes CREI training as a proven program for personal advancement in the field of Radio-Electronics. Complete details of the home study courses sent on request . . . ask for 36-page booklet.

### CAPITOL RADIO ENGINEERING INSTITUTE

E. H. RIETZKE, President

Home Study Courses in Practical Radio-Electronics Engineering for Professional Self-Improvement

Dept. CO-8, 3224-16th St., N. W. WASHINGTON 10, D. C.

Contractors to the U. S. Navy—U. S. Coast Guard—Canadian Broadcasting Corp.—Producers of Well-trained Technical Radiomen for Industry.

interior surface sand-blasted. Lenses are also available without sand-blasting in clear glass.

Socket is of the screw candelabra base type for use with the T4½ neon glow lamp bulb, as well as with the S6 tungsten bulb.

The D/E type lens-cap is also available with socket sections for use with other type lamp bulbs, such as the 555 D/E unit for G6 double-contact bayonet base bulbs, and the T3 D/E unit for single-contact miniature bayonet base T3¼ lamp bulbs.



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#### CLAROSTAT WIRE-WOUND CONTROLS

A new version of the type 58 Clarostat wire-wound potentiometer or rheostat has been released by Clarostat Mfg. Co., Inc., 285-7 N. 6 St., Brooklyn, N. Y.

The new model has a metal strap on the shaft face, providing for a two-position locating pin. Metal strap also grounds the metal cover which is clinched to it. The cover is keyed in place on the casing. The bushing is keyed into the bakelite case. Uses high-grade molded bakelite.

The center rail and terminal comprise one piece. There is also a direct connection between winding and the *l* and *r* terminal lugs.

There is zero hopoff at terminal; 1500-volt breakdown insulation between winding and shaft. Switch can be added. Tandem units with two or more controls on common shaft, are available. Ratings: linear, 3 watts; V and W tapers, 2 watts; L, N and U tapers, 1.5 watts. Resistance values: linear, 1 to 75,000 ohms; tapered, 10 to 50,000 ohms.

\*\*\*

#### STACKPOLE BRAZING CARBONS

A treatment to increase the life of resistance welding or brazing carbons has been developed by the Stackpole Carbon Co., St. Marys, Pa. The treatment, known as "P" treatment, is said to reduce the need for frequent dressing of the carbons by two-thirds or better.

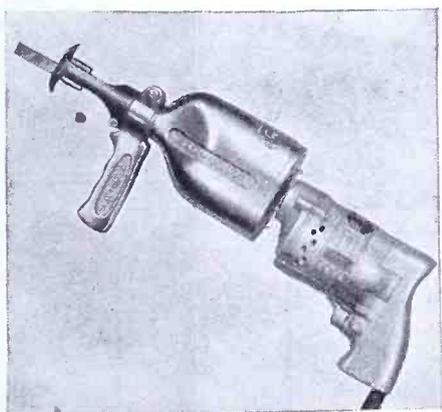
The new units are said to operate satisfactorily at brazing temperatures above red heat. Available in all shapes and sizes. Samples for test will gladly be sent to large users who request them on company stationery.

\*\*\*

#### CHICAGO PRECISION ELECTRIC DRILL SAW AND FILE UNIT

An attachment for electric drills that is said to provide a portable power saw and file. has been announced by Chicago Precision Equipment Company, 919 N. Michigan Ave., Chicago 11, Illinois.

According to the manufacturer, the new device will saw into metal, casting or rod, wood, plastics and other materials, by placing an ordinary hack-saw blade in the holder with the teeth toward the operator.



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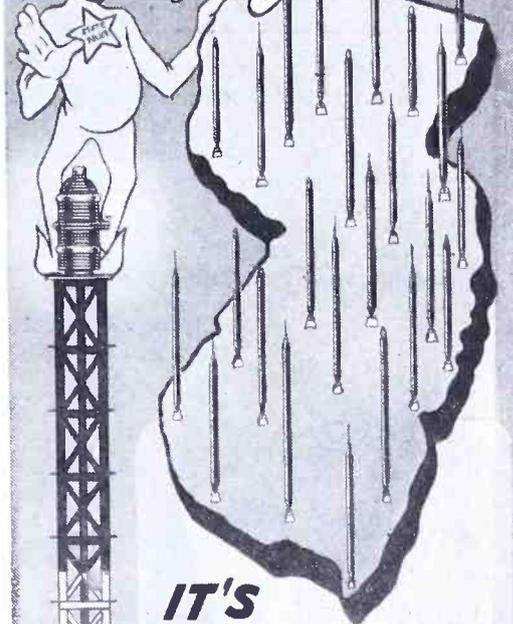
#### VOLT-OHM MILLIAMMETER

Six a-c/d-c voltage ranges, 7 d-c ranges, 5 resistance ranges and an a-c range are provided in a volt-ohm milliammeter developed by Superior Instruments Co., 227 Fulton Street, N. Y. 17, N. Y.

The d-c and a-c voltage ranges, at 1,000 ohms per volt, are 0 to 15/60/150/300/600/1,500. Current ranges (d-c) are 0 to 3/15/60/150 ma; 0 to

(Continued on page 90)

IN New Jersey



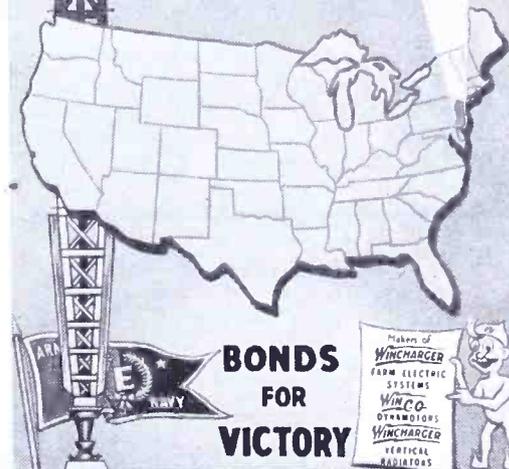
## IT'S WINCHARGER TOWERS

FOR STATE POLICE RADIO AND F. M. SYSTEMS

For their outstanding Radio Communication System, the New Jersey State Police use Wincharger Towers exclusively as supports for F-M Antennas. They and hundreds of other stations in all types of broadcasting know that they depend on Wincharger for ---

- ★ Strong, Clear Signals
- ★ Low Initial Cost
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Immediate deliveries on suitable priorities. Write or wire for full information.



# WINCHARGER

ANTENNA TOWERS and VERTICAL RADIATORS

WINCHARGER CORPORATION SIOUX CITY, IOWA

# ELECTRICITY

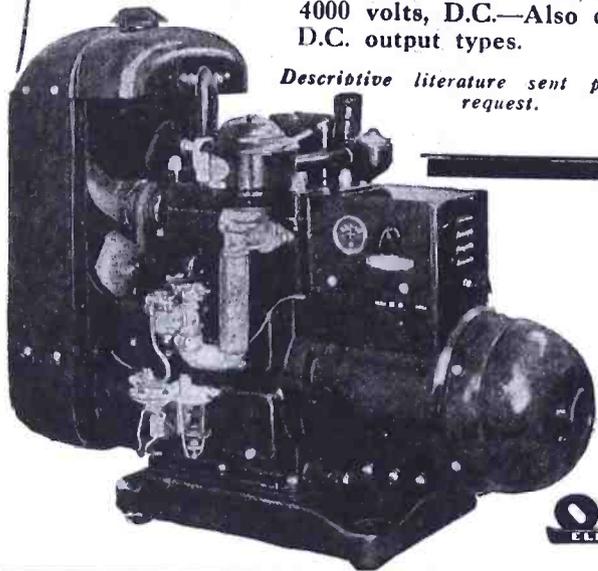
For Any Job—Anywhere

For a dependable source of electricity on projects remote from commercial power, Onan Electric Plants are proven leaders in the field. More than half of the armed forces' total requirements for Power Plants are built by Onan.

Gasoline-driven. . . . Single-unit, compact design. . . . Sturdy construction. . . . Suitable for mobile, stationary or emergency service.

Over 65 models, ranging in sizes from 350 to 35,000 watts. 50 to 800 cycles, 115 to 660 volts, A.C.—6 to 4000 volts, D.C.—Also dual A.C.-D.C. output types.

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D. W. ONAN & SONS

1271 Royalston Ave. Minneapolis 5, Minn.

**ONAN**  
ELECTRIC PLANTS

## Lister Electronic Products

1814 E. 40TH ST. CO. CLEVELAND 3, OHIO

Development and Manufacture of  
TRANSMITTERS AND RECEIVERS, AM AND FM  
INDUCTION HEATING FURNACES  
ELECTRONIC GAUGING EQUIPMENT  
INDUSTRIAL ELECTRONIC EQUIPMENT

# Radio AND ELECTRONIC DEVICES



**BURSTEIN-APPLEBEE CO.**

1012-1014 McGee St. • Kansas City 6, Missouri

CRYSTALS EXCLUSIVELY



SINCE 1934

ORDERS SUBJECT TO PRIORITY  
PETERSEN RADIO CO., Council Bluffs, Iowa

## ACOUSTICAL SOCIETY REPORT

(Continued from page 38)

source on a steel track, the position of the microphone being remotely controlled by *Selsin* motors. The positions of equal phase are recorded by photographing a reference scale against a steel tape

Figure 4, below  
Block diagram of components in phase measuring assembly, analyzed by Professor Leonard.

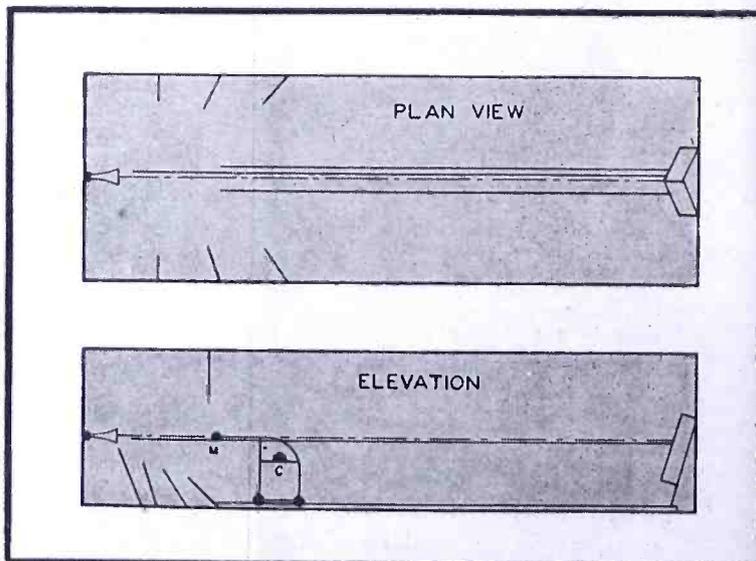
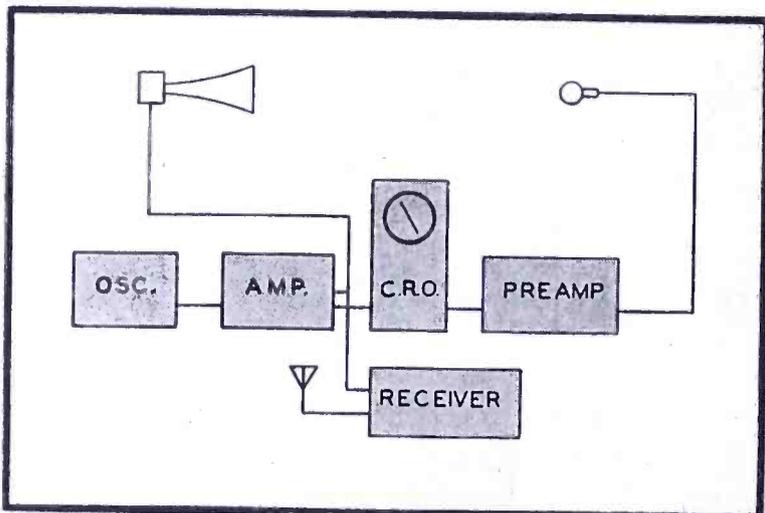


Figure 5  
Plain and elevation views of the room in which measurements discussed by Professor Leonard are made. The walls and ceiling of the room are covered by 2" of rock wool backed by 6" air space. The ceiling of the room is several feet below the surface of the ground, which accounts for the minute variations, which are of the order of .03° C. during the day.

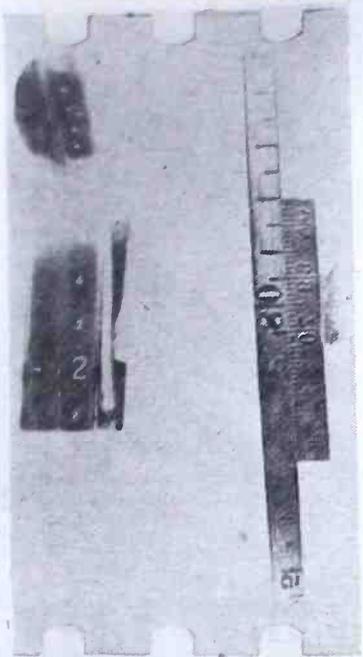


Figure 6

A typical photograph revealing the simultaneous recording of temperature and distance measurements on film. Camera is actuated by a solenoid when the proper position of the microphone is located by the pattern on the scope. Note: This negative was reversed. The tape should read from left to right.

stretched parallel to the axis of the source. The camera and reference scale move with the microphone. Wavelength measurements are made over an interval of 10 meters. The source frequency is determined by beating one of its harmonics with the carrier frequency of a commercial broadcasting station. Harmonics of the order of the 100th are generated in a suitable diode circuit.

Temperature measurements are made by means of thermocouples distributed along the line of measurement. Humidity is determined by a gravimetric method. A sample of air of known volume is passed through a drying tube and the change in weight of the tube determined. Since it is unnecessary for the operator to enter the room during or immediately previous to making the measurements, temperature gradients and turbulence are at a minimum.

Professor Leonard stated that he felt the method used has a greater potential accuracy than any yet employed for three reasons. First, it reduces to a negligible amount the diffraction effects of a large source. Second, with the proper treatment of the walls now planned, reflections will have no measureable effect on the average wavelength. And third, the room in which the measurements are made has a unique temperature and humidity stability.

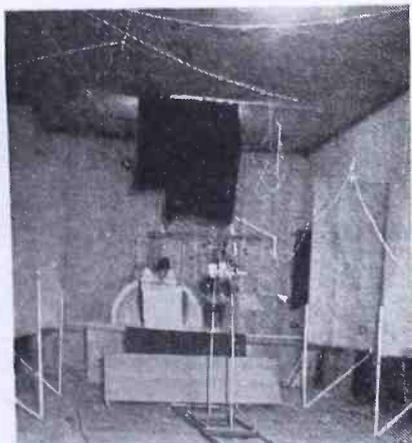
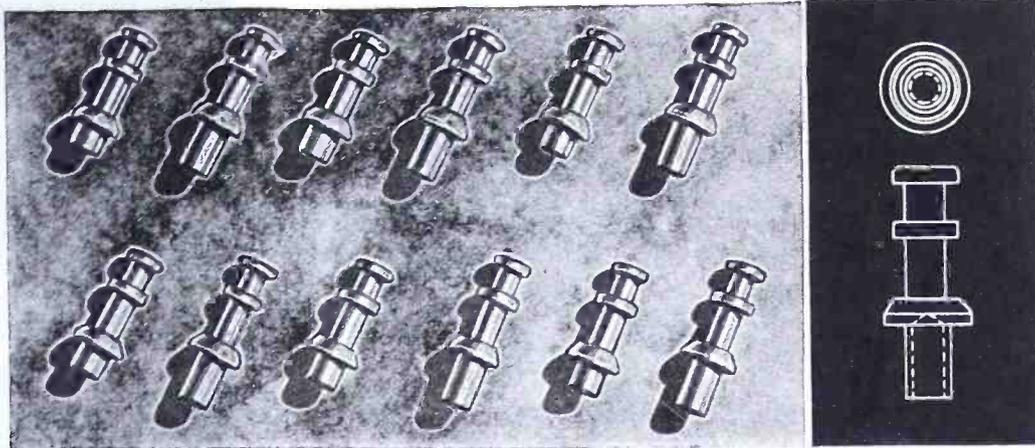


Figure 7

Room interior, looking toward sound source. Cart carrying the microphone and camera is at far end of the track.



## Short Cut to TURRET TERMINALS

C.T.C. TURRET LUGS fill the bill when you want swift, sure, easy-to-apply terminals. Just swage them to the board and in a jiffy you've got uniform, firm terminals.

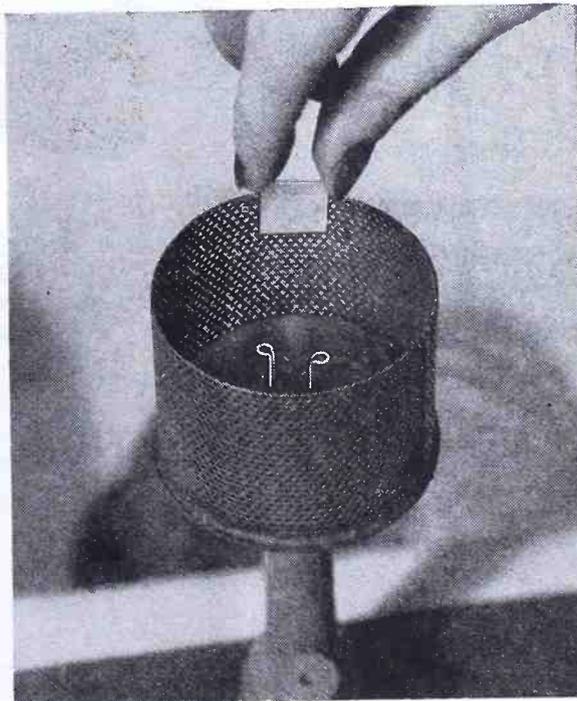
These heavily silver plated TURRET LUGS are easy to solder to and contact is perfect. The amount of metal used in their construction has been carefully calculated to give them maximum strength, yet not enough is used to draw heat, thus slowing down the soldering operation.

No time lost getting them, either. TURRET LUGS to fit a wide range of terminal board thicknesses are stock items with us. Just specify the thickness you require and we'll send them on their way to you in a hurry. Write, phone or wire



**CAMBRIDGE *Thermionic* CORPORATION**  
445 CONCORD AVENUE • CAMBRIDGE 38, MASS.

## A New TWIST TO CRYSTAL CLEANING



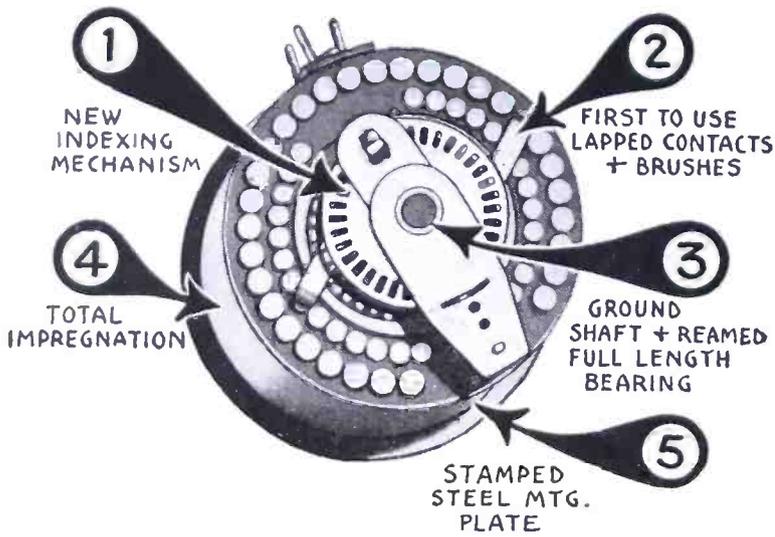
**T**HIS is an actual photograph of the centrifugal air drier, or "spinner," used in Bliley production to facilitate clean handling of crystals during finishing and testing operations. Quartz blanks are dried in 5 seconds in this device which is powered with an air motor and spins at 15,000 r.p.m.

Little things like lint or microscopic amounts of foreign material can have a serious effect on crystal performance. The "spinner" eliminates the hazards encountered when crystals are dried with towels and makes certain that the finished product has the long range reliability required and expected in Bliley crystals.

This technique is only one small example of the methods and tests devised by Bliley Engineers over a long period of years. Our experience in every phase of quartz piezoelectric application is your assurance of dependable and accurate crystals that meet the test of time.

BLILEY ELECTRIC COMPANY . . . ERIE, PA.





## 5 MAJOR INVASION POINTS

WIN FOR **VARIATEN** IN THE  
**VARIABLE ATTENUATOR FIELD**

Point No. 1 — New, positive indexing mechanism with steel ball smooth operation and phosphor-bronze spring.

**CINEMA ENGINEERING CO.**

1508 W. VERDUGO AVE. • BURBANK, CALIF.

# AMPEREX

WATER and AIR COOLED  
 TRANSMITTING and RECTIFYING TUBES

AMPEREX ELECTRONIC PRODUCTS  
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 Export Division: 100 Varick Street, New York, U. S. A. Cables: "ARLAB"

Continuously  
 Since 1930

PRECISION GROUND

*Crystals*  
 BY  
**HIPOWER**

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 MARINE • BROADCAST  
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**HIPOWER CRYSTAL COMPANY**

Sales Division — 205 W. Wacker Drive, Chicago 6  
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## Girl Saves Man Hours!

**Making Parts Without Dies**

No delay waiting for dies—parts ready quicker—deliveries speeded up. Women are rapidly taking a major place on the industrial front. DI-ACRO Precision Machines—Shears, Brakes, Benders—are ideally suited for use by women in making duplicated parts accurate to .001" —

Write for catalog—  
 "DIE-LESS DUPLICATING."



DI-ACRO BRAKE forms non-stock angles, channels or "Vees". Folding widths—6", 12", 18"



◀ Pronounced "DIE-ACK-RO"

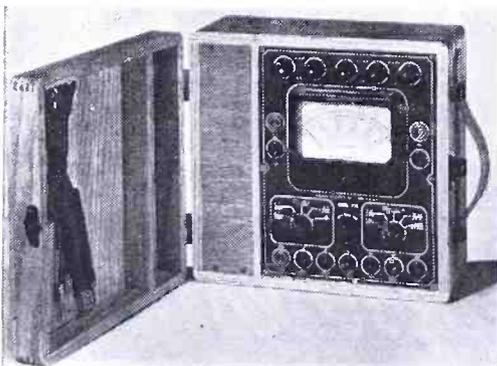
**O'NEIL-IRWIN MFG. CO.**

322 EIGHTH AVE. SO., MINNEAPOLIS 15, MINN.

## THE INDUSTRY OFFERS ... —

(Continued from page 87)

3/15/30 amperes. The a-c range is 0 to 3 amperes. Resistance ranges are 0 to 1,000/10,000/100,000 ohms and 0 to 1 megohm. Meter is 4 1/2" square, 0-400 microamperes. Size, 6" x 10" x 10"; weight, 11 pounds.



## A-N STANDARDIZATION

(Continued from page 37)

at 85°, for example, ± 200 parts per million per degree Centigrade =

$$\frac{\pm 200}{10^6} \times 100 (85^\circ - 25^\circ) = \pm 1.2\%$$

or at -43° C

$$= \frac{\pm 200}{10^6} \times 100 (-40^\circ - 25^\circ) = \pm 1.3\%$$

This chart should prove helpful to design engineers in selecting capacitors re-

quiring definite limits of capacitance—change with temperature. It is no longer necessary to have numerous charts and data sheets showing the temperature characteristics of several manufacturers' types of capacitors.

### Capacitance

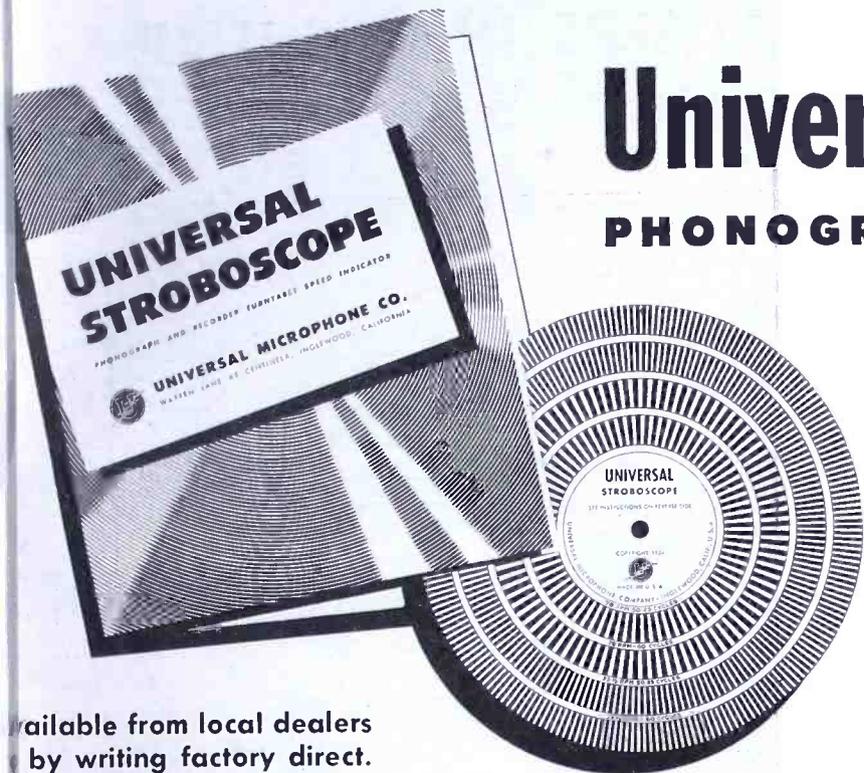
Standard capacitance values in micro-microfarads are denoted by a three-digit numerical code. The first two digits are the first two significant figures; the third digit is the number of zeros which follow: 050 = 5 mmfd; 513 = 51000 mmfd.

### Tolerance

Standard tolerance values are all sym-

# Universal Stroboscope

## PHONOGRAPH AND RECORDER AID



This handy phonograph turntable speed indicator, complete with instructive folder, is now available gratis to all phonograph and recorder owners through their local dealers and jobbers. As a recorder aid the Universal Stroboscope will assist in maintaining pre-war quality of recording and reproducing equipment in true pitch and tempo.

Universal Microphone Co., pioneer manufacturers of microphones and home recording components as well as Professional Recording Studio Equipment, takes this means of rendering a service to the owners of phonograph and recording equipment. After victory is ours—dealer shelves will again stock the many new Universal recording components you have been waiting for.

Available from local dealers  
by writing factory direct.

*Yours for the asking!*



metrical and designated in accordance  
with the following table:

- G = ± 2%
- J = ± 5%
- K = ± 10%
- M = ± 20%

A typical *standard* type designation would thus be *CM20B471M*. This designation gives a complete description of the unit—maximum dimensions 51/64" × 15/32" × 7/32", B characteristic, 470 mmfd capacitance and ± 20% tolerance.

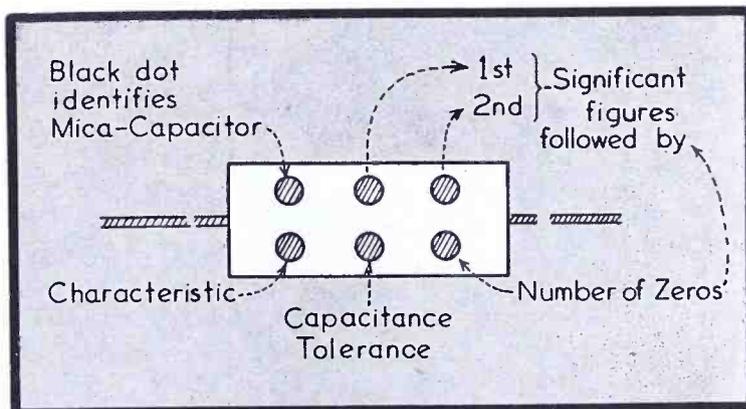
Each *standard* type designation carries a specific voltage rating as listed in the specification. For this reason the need for a voltage indicator is unnecessary in the type designation or the color code. The voltage table shows the standard voltage ratings for ranges of capacitance in each case size. It is to be noted that case sizes *CM35* and larger have multiple voltage ratings; the higher values of capacitance in a given case size of necessity have reduced voltage ratings.

Design engineers can now specify their exact needs for each application since the *standard* type designation itself specifies all-important electrical and physical characteristics. The designer knows that complete interchangeability between manufacturers' *standard* types is assured by specifying a *standard* type designation. Manufacturers and designers are thus on a common level and have a mutual understanding of exactly what is required and what is available.

| Color        | Capacitance      |                    | Tolerance (Per Cent) | Characteristic |
|--------------|------------------|--------------------|----------------------|----------------|
|              | Significant Fig. | Decimal Multiplier |                      |                |
| Black .....  | 0                | 1                  | 20 (M)               | A              |
| Brown .....  | 1                | 10                 | 2 (G)                | B              |
| Red .....    | 2                | 100                |                      | C              |
| Orange ..... | 3                | 1,000              |                      | D              |
| Yellow ..... | 4                |                    |                      | E              |
| Green .....  | 5                |                    |                      | F              |
| Blue .....   | 6                |                    |                      | G              |
| Violet ..... | 7                |                    |                      |                |
| Gray .....   | 8                |                    |                      |                |
| White .....  | 9                |                    | 5 (J)                |                |
| Gold .....   | ..               | 0.1                | 10 (K)               |                |
| Silver ..... | ..               | .01                |                      |                |

Figure 3

At right, color coding guide. (Arrow following word "zeros" should be reversed.) The color code chart is shown above.



# AUDAX

RELAYED-FLUX  
Microdyne

Long before this war began  
AUDAX Pickups were in

## SELECTIVE SERVICE

Since pickups first became important commercially, the distinguished products of AUDAX have been SELECTED wherever and whenever the requirements were exacting.

Today AUDAX magnetically powered pickups are SELECTED for War contracts that demand the highest standards of performance . . . irrespective of climatic variations or severe handling.

Our stern peacetime standards, maintained for so many years, have proven comfortably adequate to meet government specifications.

The sharp, clean-cut facsimile reproduction of MICRODYNE is a marvel to all who have put it to the only test that really matters . . . the EAR TEST.

### AUDAX COMPANY

500-C Fifth Ave., New York 18, N. Y.

Creators of High Grade Electrical  
and Acoustical Apparatus Since 1915

Send for your copy of our informative  
"PICK-UP FACTS"

★ BUY  
WAR BONDS

"The Standard by Which Others  
Are Judged and Valued"



## ADVERTISERS IN THIS ISSUE

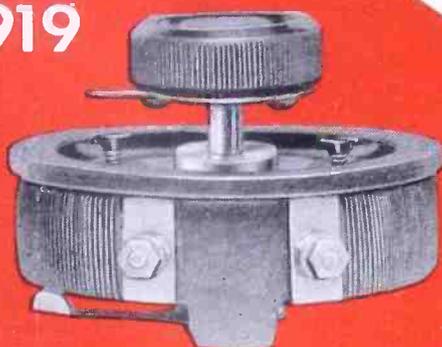
COMMUNICATIONS—AUGUST, 1944

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| ARPIN MFG. CO.                           | 70                 | LEWYT CORPORATION                             | 15         |
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| Agency: Gregory Adv. Agency              |                    | O'NEIL-IRWIN MFG. CO.                         | 90         |
| BURGESS BATTERY CO.                      | 62                 | Agency: Foulke Agency                         |            |
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| BURSTEIN-APPLEBEE CO.                    | 88                 | Agency: Shappe-Wilkes Inc.                    |            |
| Agency: Frank E. Whalen Adv. Co.         |                    | PERMOFLUX CORPORATION                         | 71         |
| CAMBRIDGE THERMIONIC CORP.               | 72, 76, 89         | Agency: Turner Adv. Agency                    |            |
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| CAPITOL RADIO ENGINEERING INSTITUTE      | 87                 | PRESTO RECORDING CORP.                        | 41         |
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| CINEMA ENGINEERING CO.                   | 90                 | RADIO RECEPTOR CO., INC.                      | 1          |
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| CLAROSTAT MFG. CO., INC.                 | 70                 | RAYTHEON MFG. CO.                             | 83         |
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| COLE STEEL EQUIPMENT CO.                 | 73                 | Agency: Albert A. Drennan                     |            |
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| CONTINENTAL DIAMOND FIBRE CO.            | 80                 | Agency: Philip Klein Adv. Agency              |            |
| Agency: The Harry P. Bridge Co.          |                    | SOLAR MFG. CORP.                              | 19         |
| CONTINENTAL ELECTRIC CO.                 | 86                 | Agency: O. S. Tyson & Co., Inc.               |            |
| Agency: Duane Wanamaker Advertising      |                    | SPRAGUE ELECTRIC CO.                          | 16, 45     |
| DIAL LIGHT COMPANY OF AMERICA, INC.      | 74                 | Agency: The Harry P. Bridge Co.               |            |
| Agency: H. J. Gold Co.                   |                    | STANDARD TRANSFORMER CORP.                    | 81         |
| EASTERN ENGINEERING CO.                  | 83                 | Agency: Burnet-Kuhn Adv. Co.                  |            |
| Agency: Wilson & Haight, Inc.            |                    | SUN RADIO & ELECTRONICS CO.                   | 85         |
| ECHOPHONE RADIO CO.                      | 59                 | Agency: Mitchell Adv. Agency                  |            |
| Agency: Burton Browne, Advertising       |                    | SUPREME INSTRUMENTS CORP.                     | 85         |
| EITEL-McCULLOUGH, INC.                   | 8                  | Agency: O'Callaghan Adv. Agency               |            |
| Agency: L. C. Cole, Advertising          |                    | SYLVANIA ELECTRIC PRODUCTS, INC.              | 88         |
| ELECTRO-VOICE MFG. CO., INC.             | 66                 | Agency: Arthur Kudner, Inc.                   |            |
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| FEDERAL MFG. & ENGINEERING CORP.         | 28                 | Agency: Lewis Adv. Agency                     |            |
| Agency: Shappe-Wilkes Inc.               |                    | THE TELEX PRODUCTS CO.                        | 75         |
| FEDERAL TELEPHONE & RADIO CORP.          | 11, 43             | Agency: Erwin, Wasey & Co. of Minnesota       |            |
| Agency: Marschalk & Pratt                |                    | TERMINAL RADIO CORP.                          | 80         |
| THE FORMICA INSULATION CO.               | 55                 | Agency: Charles Brunelle                      |            |
| Agency: The Chester C. Moreland Co.      |                    | THOMAS & SKINNER STEEL PRODUCTS CO.           | 86         |
| GALVIN MFG. CORP.                        | 31                 | Agency: The Caldwell-Baker Co.                |            |
| Agency: Gourfain-Cobb Adv. Agency        |                    | TRAV-LER KARENOLA RADIO & TELEVISION CORP.    | 76         |
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| GENERAL INSTRUMENT CORP.                 | 13                 | Agency: Western Adv. Agency, Inc.             |            |
| Agency: H. W. Fairfax Agency, Inc.       |                    | U. S. TREASURY DEPT.                          | 30         |
| GENERAL RADIO CO.                        | Inside Back Cover  | UNITED ELECTRONICS CO.                        | 23         |
| GOTHARD MFG. CO.                         | 80                 | Agency: A. W. Lewin Co., Inc.                 |            |
| Agency: Merchandising Advertisers        |                    | UNITED TRANSFORMER CO.                        | 63         |
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# YOU'VE SEEN



1919



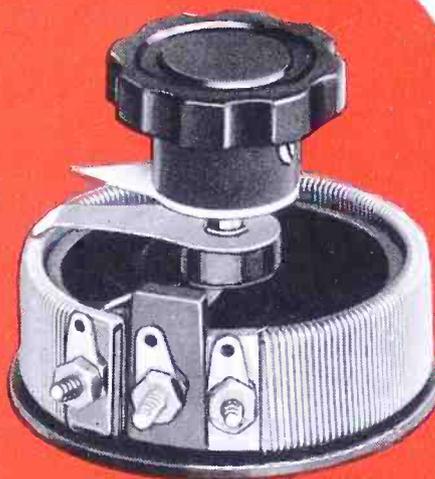
# THESE

# BEFORE

1923



1934



NOW



NO hasty development or Chinese copy of the units of some other manufacturer, the popular Types 214-314 Rheostats have been made by us for many years. The Type 214 was first brought out in its present general form in 1919. As materials improved . . . better wire . . . better insulation . . . more accurate winding methods . . . better mechanical design of molded form, winding cards and contact arms . . . the Type 214 gradually reached its present stage. They are being turned out just as quickly and in just as large volume as we are able. After the war we may have some radical improvements in our entire rheostat line. In the meantime when ordering rheostats that look like G-R, why not *buy* G-R, if our present delivery schedules meet your requirements.



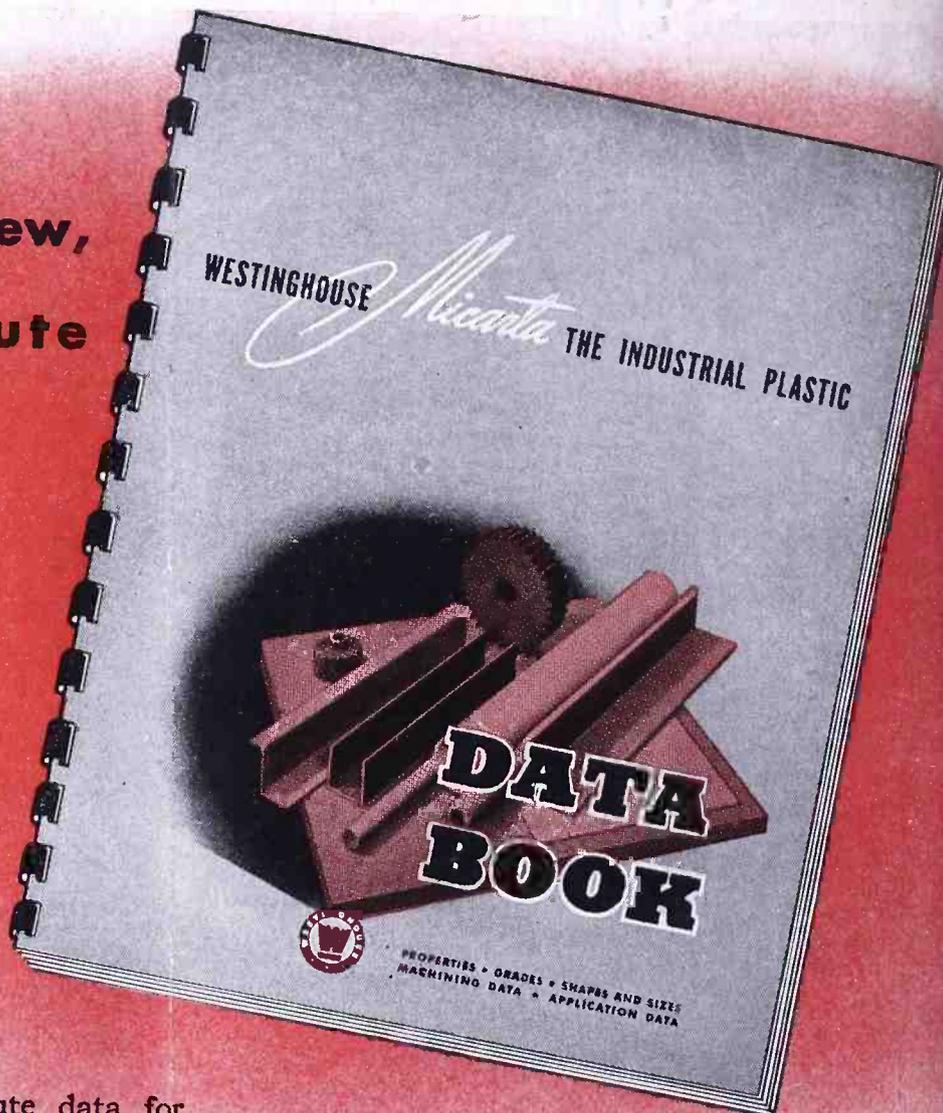
# GENERAL RADIO COMPANY

Cambridge 39, Massachusetts  
NEW YORK CHICAGO LOS ANGELES

**40** pages of new,  
up-to-the-minute

*facts*

FOR  
**COMMUNICATIONS  
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